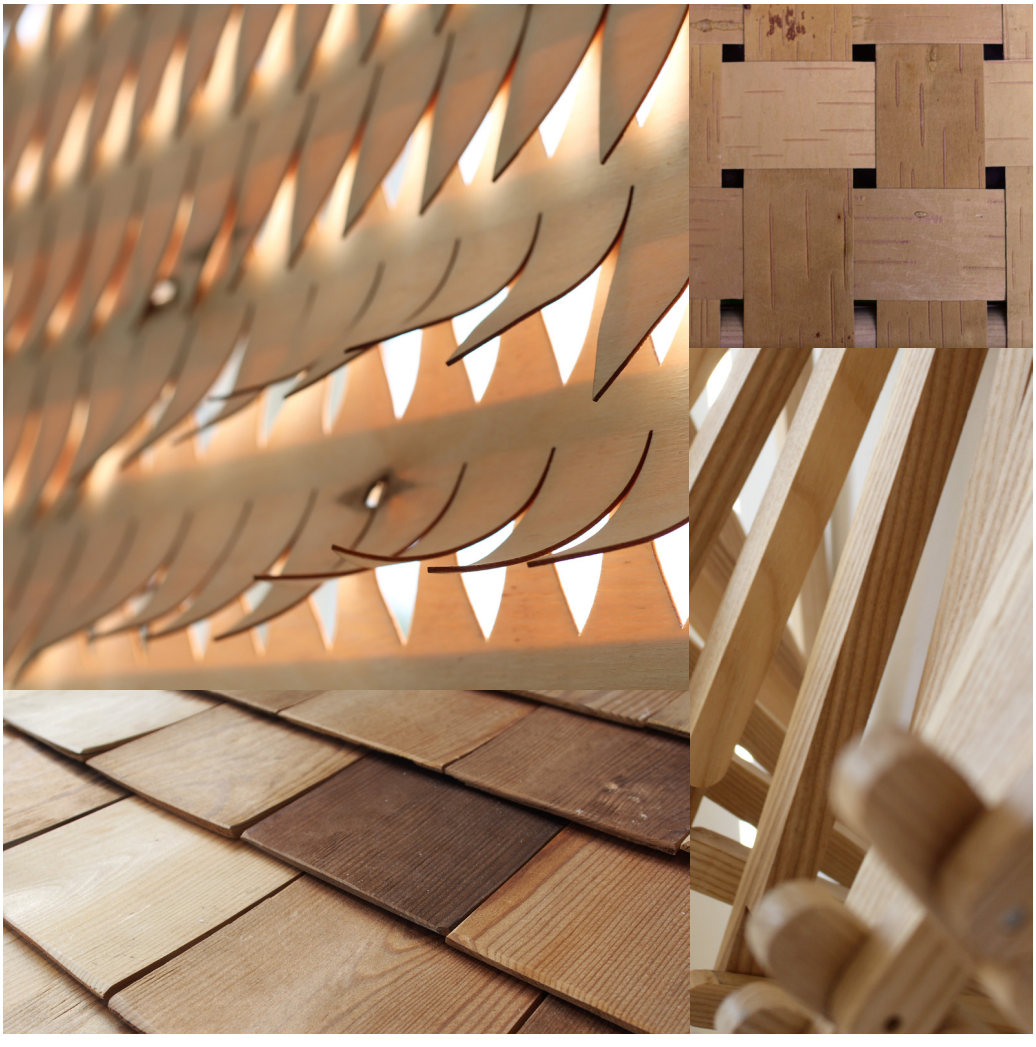
School of Arts, Design and Architecture

Functional Wood

Yrsa Cronhjort, Mark Hughes, Mikko Paakkanen, Karola Sahi, Pekka Tukiainen, Tomi Tulamo, Katja Vahtikari (eds.)



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Introduction

Functional Wood Materials, Surfaces, Products and Systems for Interior Use

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We spend the majority of our time indoors. The importance of interior air quality is increasing and links directly to our physical and mental wellbeing. Indoor climate is affected by, amongst other things, the use, the spatial design, building technology and material choices.

Temperature and moisture are central characteristics of interior spaces and research suggests that these can be affected by the choice of surface materials. Wood's propensity to interact with moisture can be put to good effect in helping to mediate the interior environments of buildings. As the humidity level rises, wood adsorbs moisture from the surrounding air and, when the humidity drops, the stored moisture is released back to the environment. In this way wood acts as a 'buffer', helping to reduce large fluctuations in relative humidity, making for a more comfortable living environment. Associated with adsorption there is a release of heat which can raise the surface temperature of wood; conversely heat is required during desorption. These processes combined with other thermal properties of wood give rise to the concept of hygrothermal mass, which may have the potential to improve the energy efficiency of buildings. Additionally wood feels warm (or cool as anybody who has sat in a hot sauna will know!), a characteristic that can help improve human thermal comfort in the space. These attributes, and others, are gradually being recognized and there is greater and greater interest in the use of wood for interior spaces.

Interior air quality is affected by, for example, volatile organic compounds (VOC), air-borne particles and microbes, formaldehyde and others. Sources of chemical compounds and particles include human activity, structures, surfaces, furnishings, and the air itself. Reference values for various chemical compounds and particles are defined, and values lower than these usually result from normal use and do not pose a risk to human health. The amount of formaldehyde in wood products has been nationally regulated since 1980, and in 2004 the European Standard EN 13986 established formaldehyde classes E1 and E2. Fresh wood has a strong odor caused by VOCs. The amount decreases drastically with the drying of the wood and over time.

The importance of interior comfort grows with increasingly energy efficient building. From January 2021 onwards all new buildings within the European Union are to be built to nearly zero energy standards (nZEB). This also affects the design of interior spaces. In various pilot projects that have been completed to date, wood has so far been used scarcely, even if the characteristics of wood materials support the creation of a pleasant space. Empirical studies have shown that wood is perceived to be a pleasant, warm, breathing, and timeless material.

In addition to economically and ecologically sound living spaces, future social sustainability requires accessibility and comfort in our living and care environments, so as to support human wellbeing. The aging population must be recognized in interior design. Basic requirements concern design for all, good acoustics and interior air quality. Wood supports the feeling of home; it is a familiar material, and the warm surface increases comfort. Northern softwood has a natural look experienced as calming and soothing.

Design has been recognized as a key discipline to bring ideas to the market. In addition to current research on human perceptions and the functional capacities of wood, this publication demonstrates the potential of wood in various applications. The designs are the results of three design courses, implemented during 2015 and 2016 at Aalto University in Finland. The Masters student courses included two Wood Studios at Aalto University's School of Arts, Design and Architecture and the Integrated Interior Wooden Surfaces course at the School of Chemical Technology at Aalto University. The students that participated in these courses have backgrounds in architecture, design and forest products technology.

This book is also the result of two research and development projects; Competitive wood-based interior materials and systems for modern wood construction, Wood2New (2014-2017) and Energy-efficient living spaces through the use of wooden interior elements, Wood Life (2013-2017). More information and publications are available on the project websites www.wood2new.org and aef.aalto.fi. We hope you enjoy our product and become inspired!

Young Designers Take Over Wood Spa Design

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Mikko Pakkanen

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What kind of positive impacts can wood used in wet spaces bring forth?

A number of studies show that wood utilized in an indoor context has positive effects on the well-being of people using the environment. Our main topic of interest is how the multi-functional prop-erties of wooden materials can be used in a spa interior in order to promote the positive impact of design on human health. Wood lives alongside its immediate environment. Wood materials both bind moisture and balance humidity differences. Wooden products enhance indoor air quality in-cluding moisture and thermal buffering and improve the acoustic properties of the space in question. Wood is a healthy material. It is antibacterial, durable and natural. Wood plays a surprisingly impor-tant role in creating psychological well-being. The use of wood can also be therapeutic because of its aesthetic and haptic properties.

How about the challenges the use of wood in wet spaces involve? When wood is used indoors, its vulnerability and the alterations it goes through are comparable to its utilization outdoors. The behaviour of wood is sometimes difficult to foresee. Chemical and mechanical treatments make it possible to control changes and minimize swelling and cracking by improving the properties of wood. The demand for surfaces that can be cleaned well set limits on wooden products. Preventing a wet surface from becoming slippery is an obvious demand for safety reasons. When continuously exposed to humidity, wood may start gathering mould. In these kinds of special circumstances wooden products require care and maintenance. But all these requirements are likely to be met with knowledge and creative design.

What are the students´ interests when examining wood in wet spaces? Our approach is experimental and includes a lot of testing of ideas and materials to study the possibilities and re-strictions of using wood. For example, larch timber planks were literally kept under a shower to see their maximum natural bending regarding the way the material was sawn. The swelling of wood was tested in a wet environment as an opportunity to use a joint that becomes stronger with an increase of moisture. The product families being studied are new kinds of elements that can be assembled for floor, wall and ceiling surfaces and individual wooden spa furniture or interior products. Spa products offer a choice between natural, modern, ergonomic and aesthetic design. For most of the products, the students have favoured massive wood like spruce, larch, elm or ash instead of modified or processed wood products. They have utilized traditional wood working methods like grab rail profiles made by steam bending or a bath seat of birch bark made by weaving. Other tradi-tional, natural treatments like charring the surface of the wood have also been utilized to improve its resistance to water and humidity. Some students have had a functional scope,

others have preferred to think of wood as a sensual experience, an enjoyable bath session promoting wellbeing.

Will wooden wet spaces become a part of our everyday life? Why not! Our bathing culture is looking for new dimensions. The shift towards ecological thinking and sustainable devel-opment support the use of wood. Wood-based products with appealing design will have added value because it decreases our carbon foot print. As the students´ concepts point out, the creation of healthy, sustainable and novel wooden spa interiors and inventive products for wet spaces opens up a world of new opportunities.

Wet Wood

1

A Wooden Shower

Eve Zorawska

The wooden shower project was inspired by one's sensation and experience of wood in a relaxing environment with the intention of bringing wood into a spa setting. Wood, and in this design case larch, has a variety of smells, texture and added warmth. This simple shower aims to capture and continue the sauna aesthetic and atmosphere outward, in both indoor and exterior applications, with curved decking for comfort and warm design.

The floor decking has been individually curved, for comfort and a softer aesthetic with spaces, with cleaning in my mind. The wall is decked with angled pieces which prevent moisture lingering within the pieces, preventing rot and damage as well as giving faster drainage.

Winter bath

Suihkupalju

Mathias Björkman

Suihkupalju is a mix between a small bath, shower stool and a wooden hot tub. The name is a combination of a shower ('suihku' in Finnish) and a hot tub ('palju' in Finnish). The idea of the bath came from my own bath and shower experiences. Showering is a more ideal way to get clean, but it is not as relaxing as a bath. With a small bath you save water and get a similar relaxing experience as you get in a normal bath.

The bath can be used indoors or outdoors, for example in a bigger shower space. This is a bath were you sit, which means you don't need a lot of space for your feet. The walls are tilted with different angles to get the perfect balance between the needs' of the lower and the upper body for space. The back wall is higher than the front wall and functions as a backrest.

The material is larch (Larix sibirica). Larch is used primarily for outdoor structures for example traditional boat building, windows, doors and jetties. Most of the larch material I used is hard and fine heartwood which suites the purpose very well.

The corner joints are butterfly joints which make the corners really strong and tight. The walls are joined together with tongue and grooved joints. All parts are glued together with Cascol Polyurethane which is water resistant.

The bottom uses the same principle as a boat deck and has space between the boards. The space between the boards is filled with black Sikaflex-11 FC which makes the bottom waterproof. The bottom is tilted backwards and on the back wall there is a hole for emptying the bath.

Suihkupalju is a small bath crafted in larch. The idea is to save water and still have the possibility to take a relaxing bath.

The bath is made as small as possible, but to maintain the comfort. The volyme of the whole bath is 0,25 m3 and the maximum amount of water is 150 litre. In the future production, the product can be produced at different scales to fit different sizes of people.

A removable bench is placed on the inside of the bath. Removing the bench gets you lower inside the bath.

The outer walls are burned and this creates a contrast between interior and exterior. A burned surface is more mould resistant and gives the product a raw look. The final finishing of the whole bath was made with paraffin oil.

Feel free to fill the Suihkupalju with warm water, jump in and have a relaxing time!

Top and side view

Creator taking a bath

Nicklas Ivarsson
Satoshi Iiyama
Aarni Aspi
Alexander Barstad
Akin Cakiroglu
Kristin Ekkerhaugen

Finnish Ofuro

Inspired by the Japanese Oforu bathtubs, we wanted to design and build our own Finnish version, by taking the strengths from the Japanese version and adapting it to Finnish conditions. The Ofuro has an important place in the home and is part of the daily bathing ritual. It is important to clean oneself thoroughly before using it. Apart from the ritualistic nature of the soaking, it is also rumoured to have beneficial health effects, such as increased blood circulation, decongestion, and soothing of the nervous system. The Ofuro is therefore often used in Japanese Spas and Bathhouses as a form of Aromatherapy.

The Ofuro tubs are constructed using techniques that are a combination of fine carpentry and boatbuilding. The bathtubs are usually rectangular in shape and big enough to fit one person, submerged to just above their shoulders and seated with their legs stretched straight out. It is traditionally made using wood from the Hinoki tree, or Japanese cypress, a highly sought-after evergreen species.

DESIGN PROCESS

A full-scale Ofuro is naturally pretty big, so for the design and testing phase we first built a smaller version of the whole Ofuro. In this way we could fill it with water, soak it and do similar tests in a better way. For this smaller model we scaled down the size of the unit, and although the ratio between the different elements were not the same as in the full size model, it turned out to be the best way to test both different joints, connections and thicknesses at the same time. We also tested this model in a heating oven.

WHAT

Wooden soaking tub

SPECIES

Finnish pine heartwood

Finnish aspen

SIZE

Model: 600x600x 600 mm

Entire tub: 880 mm wide, 1360mm long, 600 mm high

CONNECTIONS

Tongue and groove, lap joint, dowel

TREATMENT

Paraffin Oil or other natural oil

The biggest challenge with using wood in a bath tub like this is how we could prevent the water from leaking out through gaps between the members. Inspired by the traditional ways of solving this, we tested different types of dowel connection and corner joints and also tried to change these so that they would be even better. We tried to combine details from Japanese tradition with details from log construction in the Nordic countries and tested different options here. We wanted our Ofuro to be a Finnish version of the traditional Japanese Ofuro, and one of the elements we wanted to change was therefore the wood species. We ended up using heartwood of pine, because of the large amount of resins makes the wood naturally resistant to moisture and mould. Pine is readily available here in Finland and the heartwood has many similarities with the Hinoki, Japanese Cypress, used to make Ofuros.

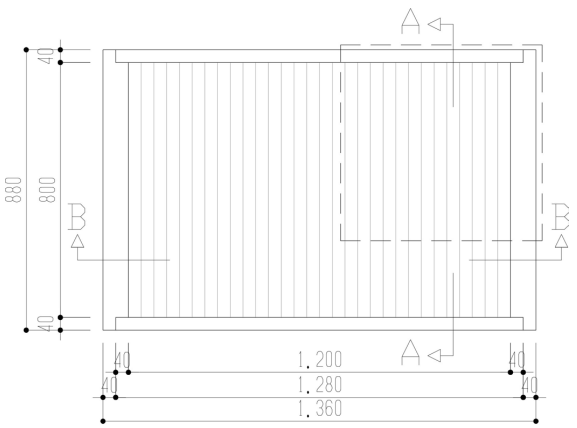
FINAL MODEL

An Ofuro is meant for bathing and relaxing in and it needs to be quite big. For this project we therefore decided to plan the Ofuro in full-scale and show this solution in drawings, while our final model shows a corner section of the bathtub. The corner will show two walls and the floor in section, which also allows us to present the connections and the joining system we have used more clearly.

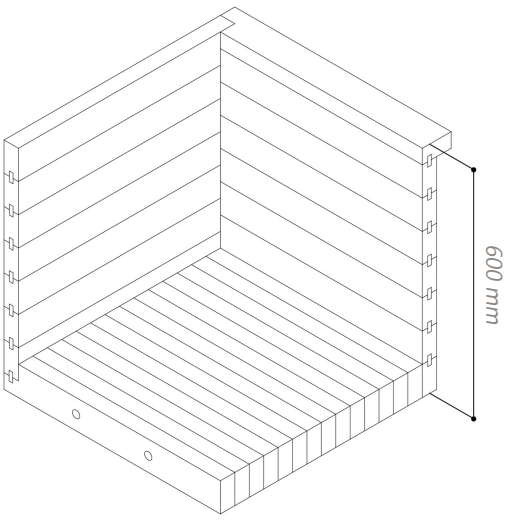
The walls are made out of massive pieces of pine heartwood, except for the ¨tongue¨ element of the tongue and groove connection in our walls, which is made out of aspen. The floor elements are also made of massive pine heartwood, but they are connected to each other with dowels made of aspen. When the Ofuro is soaked in water, these pieces will swell and increase their size and tighten the structure.

USE

To use our Ofuro, one fills the tub with warm water which releases the natural oils contained within the wood. As the Ofuro is used for soaking the body, no urethane oils are used to coat it. The pine heartwood has natural oils and resins that are emitted from the wood when wet, which protect it from rot and mould. This means that only natural oil treatments, paired with natural ventilation, are used. Paraffin oil can be used to treat the tub surface to help keep it moist and clean. It is recommended that the Ofuro be used every day and that it be emptied at least twice a week. Once empty, it should be wiped clean of excess water and then ventilated by opening a window. Keeping the tub moist through everyday use and not dry stops it from cracking or splitting and also keeps the seams of the tub tight. It is important that the Ofuro is raised off the ground so that the entire tub can be ventilated properly. Other than that, the Ofuro is fairly maintenance free!



Plan






Wooden Sink

Ivan Segato
Käbi Noodapera Ramel
María Inés Quirarte León
Maria Sundin

Is it possible to make a sink out of wood? What are the main challanges and how are they solved? For a couple of weeks we have spent time on tests, research and sketches to develop our version of a wooden sink. Our main goals were to create a sink that look nice and stay neat in use, doing it in a way that we could take advantage of wood properties. Focusing on making the manufacturing process simple and the material use efficient. The result of our work is described here, welcome to enjoy our wooden sink!

Our first challange was to find the right wood species. We wanted a hard and dense wood that could resist physical damage and handle water well. It should feel nice and smooth after cutting and processing, so the sink would stay in good condition. We started to look at dense wood species found in Finland, because of its structure –dense woods tend to have small pores which means they absorb less water. Pine heartwood contains a lot of resins and was therefore considered unsuitable. Cherry, ash, maple, oak and elm were all adequate candidates. In the end, ash was chosen since it was avalaible in our workshop.

WHY ASH?

Ash is a hardwood timber tree grown in the milder southwest of Finland, ash is one of the 27 broadleaved species in the country.

Ash was chosen, for the sink, out of the local hardwood species, with the purpose of using a material that could be accessible in Finland.

It's a dense and flexible structure, and it belongs to the category of medium high hardness wood species. It's famous for it's distinct pattern and has historically been used mainly for skis and bows. During the drying process the color of the wood gets darker; the pattern within the tree changes significantly depending on grain direction.

Another challenge for us was how to use the fibredirection qualities of wood. As stated before, ash is rather dense, but still the grain direction makes a lot difference when it comes to absorption capacity. The longitudinal direction of the wood doesn't absorb liquid as easy as the radial direction, but of course that also includes impregnation. Aesthetically we really liked the way the end grain of the wood looked, so we wanted to position it on the surface of the sink and to create a pattern with it. Thanks to the radial cut, the impregnation could go deeper into the wood in order to protect it better. A surface with a radial direction would also make the sink more resistant to physical damage.

We went through three main design lines, in our designing process, before we found our final solution. One big challenge with the design was to minimize the amount of joints and corners, so the water wouldn´t stay in unwanted places. The first design consisted of simple and flat wooden surfaces, tilted against each other to gather the water, and to protect the user from getting wet. It was easy and cheap to produce since all surfaces were flat, but our mockups weren't convincing nor the design- not even function wise. The water wasn't gathered as we wanted and the connection got weak when the glue was exposed to the water.

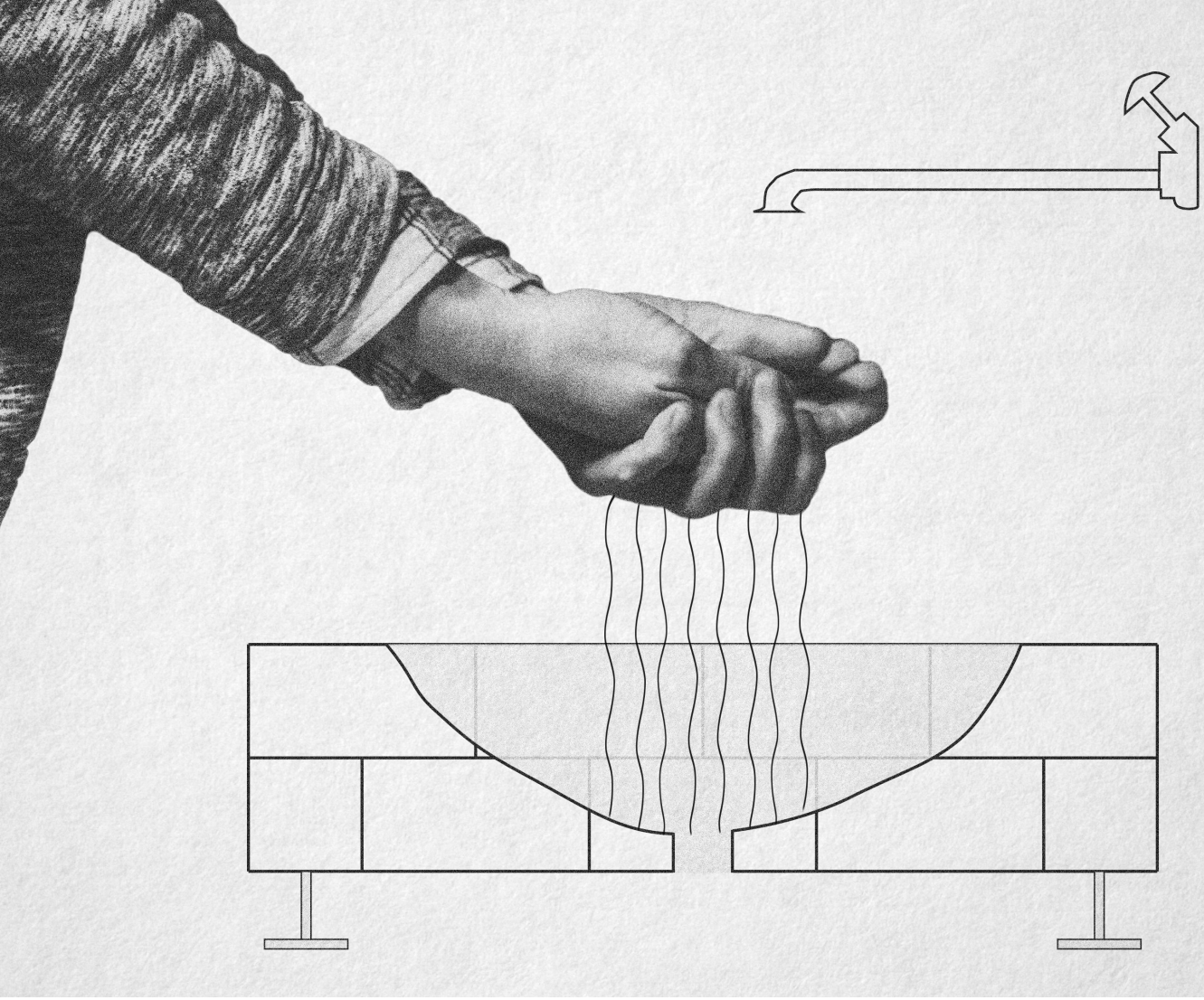
Our second design was inspired by the massive hollow logs used for cattle hydration. The long log-made sink was then meant to be connected to several taps at once. Effort was invested into finding out how to make the material use efficient, based on the production aspects. So the idea was later rejected since it wasn't coherent to use a whole log and carve the interior away for material efficiency reasons. Moreover, to imitate the log with wooden elements wasn't convincing neither both for aesthetic but also functional reasons. Adding that the simplified log had a lot of seams and didn't take advantage of the properties of wood.

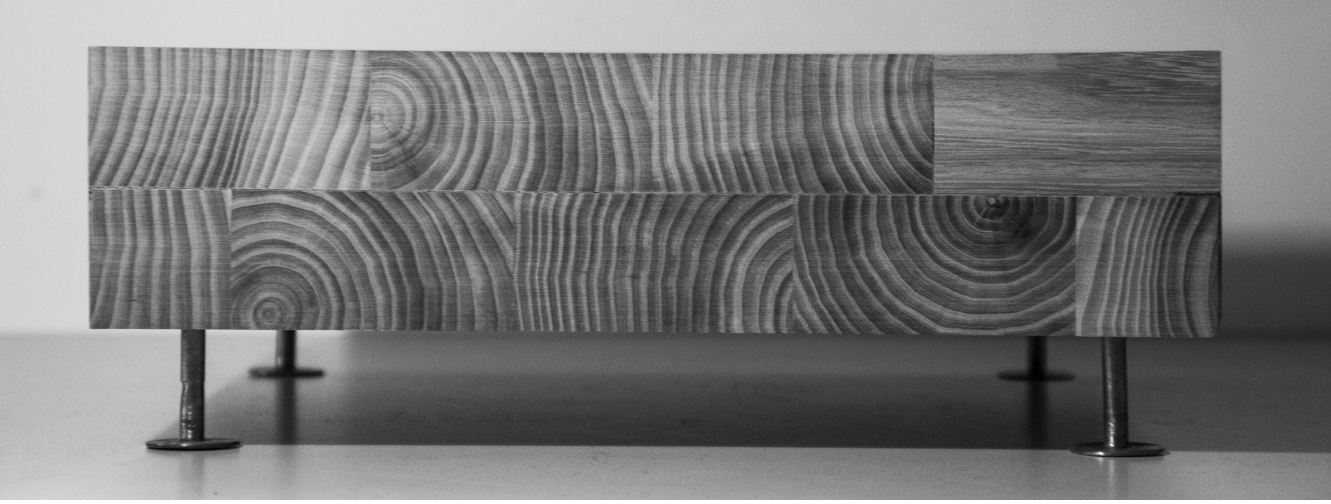
The third and final design takes the most out of the concept of the log without wasting so much material. Made from rectangular volumes of ash wood, the sink is designed to be easily installed and also moved, to facilitate the cleaning and extend the possibilities of the user's bathroom design. Slim metal legs give support, make the volume lighter and allow the wood to dry. The interplay of wooden pieces configurates the sink's volume. This volume is formed of a main core surrounded by a frame to give a gentle curved edge to style the depth. As meantioned earlier, ash is really dense, meaning that its vessels are tight and small. To be able to take advantage of the density, the direction of the wood was key in our design process. The middle piece, being the part which is the most exposed to water, needed to be prepared to absorb the finishing treatment. We exploited this idea of a main core making a beautiful pattern on the surface. The interplay of the end gray divided in rectangular volumes ended up quilting a unique surface in every face of the sink.The interlapping of the wooden volumes was drive in persuance of avoiding the joins to be on top of each other. This way we would protect the structure of the sink and at the same time distribute the loads better. Besides, it would prevent it from cracking easily. After building the first prototype, we realized that the connection of the frame to the main core was the most challenging part. Making it bowl shaped, gave us the lead to have a smooth surface so that the water could run fluidly towards the pipe.

A study of potential materials, finishing treatments, shapes and building processes was fundamental for the completition of the sink. As the studies´ results interweaved, every time the combination of the sink elements was more and more integral.

The treatment was deemed as important from the beginning. Different coatings and impregnations were tested parallel to the design development, complemented with contact with coating experts. Our requirements of the coating focused on protecting the wood from the water and dirt, furthermore to allow the growth rings to be exposed. We tried many different coatings, and the conclusion was that the environment where the sink was going to be placed had to be considered as well. If the target group were clubs and other places where people bring their wine glasses it would be a good idea to use a darker coating. Tar was tested, but it wasn´t considered because of it´s strong smell. As well, tar combined with linseed oil but it smelled worse than tar alone.

The discussion about coatings continued until rather late in the design process, and we were considering either linseed oil (that impregnates wood), boat lacquer (that creates a protective film on the surface) or a combination of both. Since compared to other hard woods ash has rather larger pores (even its dense), so the water probably would get soaked up easily even though it was treated it with linseed oil. We still wanted to keep the wood as raw as possible though, that is why we finally decided to cover all surfaces in linseed oil – to give the wood a proper impregntation. On the more exposed surfaces, meaning the actual "bowl", we decided to add boat lacquer, to be sure that the water wouldn´t stay on the surface. The metal feet that lift the sink also help it to dry properly.





So is it possible to build a wooden sink? Making a sink out of wood might not be the most long-lasting solution, but it's true that a proper design, right wood species and coating make a big difference. In the end, our wooden sink fullfiled the requirements we were looking for.

After manufacturing the first mock-up, it was obvious that the building process had to be simplified. Along with the decision of overlapping the rectangular volumes in order to avoid long seams and prevent it from cracking. Not only for aesthetic purposes, but as well for time efficiency and quality aspects.

We modeled different configurations of the piece in Sketchup, this help us find a solution and redefine the dimensions of the "cubes". First improvement was to evade cutting and gluing the elements individually. Our strategy was to divide the sink in three main elements: the core and an upper and lower frame that surrounded it. This elements would be created out of different configurations of a rectangular volume. A 44x88x88 mm piece was going to give shape to the three elements.

To build the upper frame, it was necessary to produce four 3-piece bars that would be then glued to form it. For neat lamination of the elements, we decided to cut three long bars and then glued them so afterwards we could cut the glued piece in 4. This allowed us to obtain four 3-piece bars that came from the same piece so they would be more accurate. Same process was used to form the lower frame, except that it would be four 5-piece bars. Afterwards, 45 angles were cut on their extremes so that the seams wouldn´t meet the upper frame seams.

The core, as said, was produced with the same 44x88x88 mm pieces but end-grain directed. Two long bars with a 44x88 mm sections were cut and glued longitudinally, then cut in 4. Afterwards positioned in and end-grain direction and glued together.

The elements were joined with glue. The reason behind this is that there are a lot of different surfaces which needed to be attached in several directions. Mechanical fasteners would be very costly, not at all aesthetically appealing and not practical for being used in wet spaces.

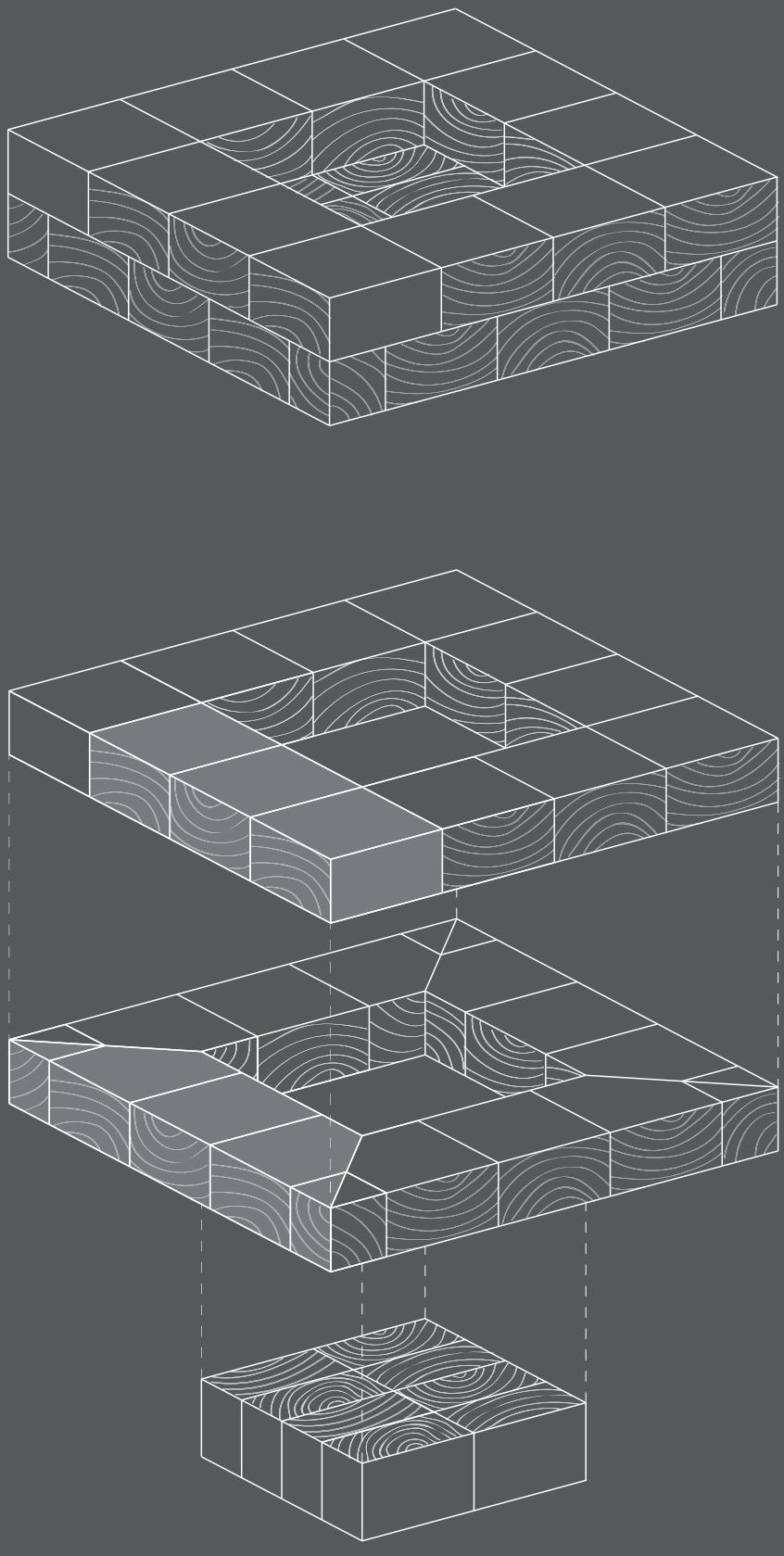
The recommended glue is polyurethane glue, which is marketed as waterproof and very strong. Further testing would be needed to determine the strength of the glue. The glue used for the demonstrational piece, which is not meant to be a functional prototype, is Trälim Ute by Bostik.

This process permitted us to accomplish a more, dimension wise, precise piece. Before connecting the three main elements, the core had to be shaped into a bowl ¬ using a route. Later, we glued the three elements together. Using a sanding hand tool, we shaped the inner part of both of the frames together with the core. As we sanded, we manage to blend the inner piece into a bowl-shaped surface. Last thing was to drill the drain hole and coat.The piece was treated with linseed oil. The "bowl" section of the sink was also treated with oil-based polyurethane, namely boat lacquer Unica Super made by Tikkurila. To finalize the piece, the metal feet were added by drilling a hole in each bottom corner and then securing them with glue.

The tests, the process and the result penetrate the strong contrast that wood and liquids have. The necessity of breathing and waterproof surfaces challenged the design and explored the properties of wood.

Cooperation between engineering and design world determined the choices that the group has taken.

The result demonstrate the progress that has been achieved in 2 months of work. Wood and its forms has always to say something new.



Wooden Wash Basin

Silje Loe

There are several reasons why spruce is a good choice for this type of wooden product. Spruce is a strong material and it works well in water. Spruce has a light and beautiful colour and has dark, but few, knots. And the best outcome from working with spruce is that this Wash Basin is incredibly light!

The Wash Basin is intended for one person to use, it is 35 cm in diameter at the top. It is not deep, it can be filled to 10-12 cm with water. The interaction with water becomes something personal, something calming. You can keep the basin in front of you to wash your face, or lift it by the handles to pour water over your body. It is lightweight and the touch of it is soft.

The walls of the basin consist of 16 cone-shaped pieces that are glued together with a V-shaped profile in between. The V-shaped profile provides a better gluing surface. It gives strength, helping to eliminate the need for a band around the basin when the force of the water pushes outward.

The handles are shaped as continuous pieces that are part of the walls. They fit together with the rest of the wall pieces with the same V-profiles. To solve the meeting between these profiles in the handle pieces, which are longer than the rest, the handle has been placed around the V-profile.

The bottom piece is a hexadecacon. It has been made 1-2 mm smaller on the sides that are perpendicular to the wood grain to allow for movement when the basin comes into contact with water.

The Wash Basin is fashioned from Spruce. The walls and the bottom of the basin are made of 1,5 mm thick pieces of Spruce, making it very light.

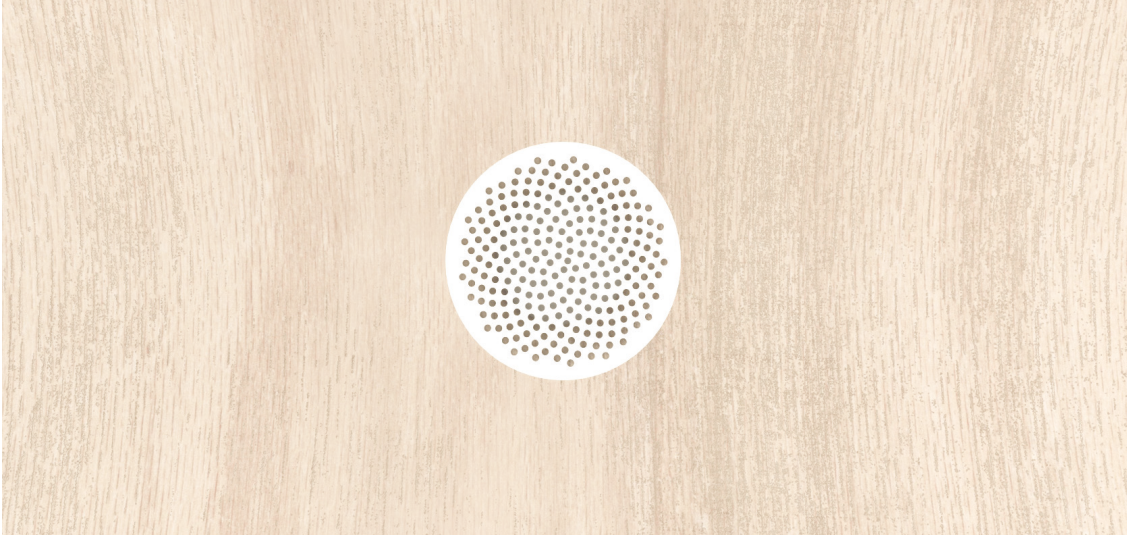
The walls consist of 16 cone-shaped pieces that are glued together with a V-shaped profile in between.

Four of these pieces continue in height, forming handles for carrying the wash basin. The handles have been shaped directly out of these pieces to keep them seemless and strong at the same time.

The bottom piece fits into corresponding slots in the wall pieces, and it has been shaped to allow movement of the wood when the wash basin is filled with water.

Detailing of the bottom of the basin.

A wooden Wash Basin including handles made from 16 pieces of spruce.



Detail view - drain cover

Asteraceae

Dario Vidal

Asteraceae is a wooden bathroom sink designed and sculpted to optimally direct water to the drain keeping the inner surface as clear of water as possible. Based on recent research, the surface of untreated wood dries faster than other surfaces like plastic or metal and also has antibacterial properties.

The metallic drain cover follows the form of the wooden surface, highlighting the continuous surface composed of two materials. The cover is ornamented with an elegant phyllotaxis pattern familiar from sunflowers and pine cones - design inspiration from nature. Asteraceae refers to a family of flowering plants, most of them featuring a phyllotaxis pattern.

The form is carved into a block of elm using a CNC milling machine and finalized by hand. The metallic drain cover was 3D printed, cast, sanded, and polished until an adequate surface finish was acquired.

The sink can be fixed into the wall or placed on an existing platform. The item sits on top of supports raising the wood from the platform, maintaining adequate ventilation in possibly moist collecting areas. The sink is an independent element and it is not in direct contact with the water tap.

Wood, an organic and sustainable material, is usually protected from moist or wet conditions. In this case, the designer's task is to challenge the common stereotype and experiment with the uncommon and uncertain, and ultimately find a suitable material-application balance.

In Finland, forests are a valuable and sustainable renewable natural resource. Covering 65% of Finnish territory, forests are deeply embedded in Finnish traditions and culture. Is this valuable resource suitable for the designer's proposal?

This piece is a prototype that studies the suitability of surface treated wood in moist conditions for a bathroom sink application.

Section view in perspective

Perspective view

Wood in Wet Spaces — Health Hazard or Sustainable Energy Saving?

Alina Lozhechnikova
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Wood is known for having a number of excellent material properties: it is strong, renewable and visually appealing. The hygroscopicity of wooden materials, however, is hardly ever considered to be one of them and in general is considered to be a drawback. Hygroscopicity is the ability of wood to adsorb, hold, and release moisture, and recent research findings show that it can be used to our advantage.

When wood is used in living spaces, its hygroscopic nature allows it to 'buffer' the indoor moisture of a building and, therefore, to even out large variations in relative humidity. Imagine having a wooden wall or ceiling that will take moisture from the surrounding air when the humidity is high and release it back when the air is drier, thus decreasing humidity variations. Maintaining a constant level of humidity will not only increase the perceived air quality, but will also enhance the inhabitant's comfort. During hot periods, for example, reduced moisture in the air (due to moisture storage in hygroscopic materials) leads to increased comfort and reduces the need for cooling. In this way, having lots of wooden material is like having a passive climate control system that regulates the indoor climate naturally and might lower the energy demand for heating, cooling, and air conditioning. Thus, using more wood increases the overall energy efficiency of the building.

At the same time, the presence of water may have a negative impact on wooden elements. Timber has a natural affinity toward water, but an excess of moisture leads to swelling of the material and cracks might form upon drying. Additionally, wet conditions create a very favourable environment for many wood-degrading biological organisms, like fungi, bacteria and insects. As a result of degradation by these organisms,

the aesthetic appeal and even the durability of wood may be greatly reduced, not to mention the health concerns related to the presence of mould in living spaces.

In order to avoid these problems of degradation and durability loss, and to make it easier to clean and maintain, wood is often modified. Modification processes that decrease the material's affinity toward water are called hydrophobization. Wooden surfaces, like floors, walls and ceilings, have a long history of hydrophobization and a variety of commercial treatments are available nowadays to protect them from water. For example, diverse lacquers, varnishes and paints. However, these paints and coatings are generally applied as a thick layer on the surface, and recent studies suggest that this would reduce moisture buffering ability of wood

The aim of our work was to develop a coating that would preserve the moisture buffering properties of wood and at the same time protect it from liquid water. Materials coated in such a way would be much easier to clean and maintain, and would allow for the greater use of wood even in wet spaces, like bathrooms and kitchens. The modification of wood was done by applying wax particles onto its surface. It is the use of particles that makes our approach fundamentally different from traditional film-forming lacquers and varnishes, and this difference is schematically shown in Figure 1.

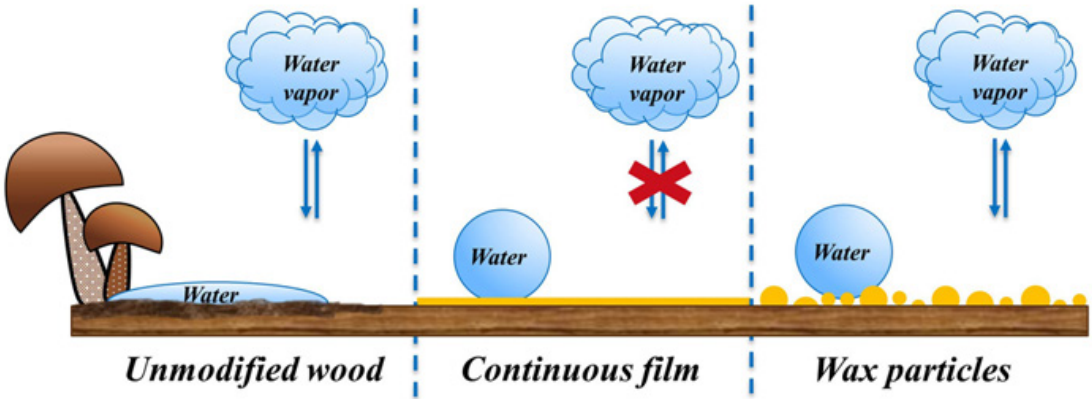
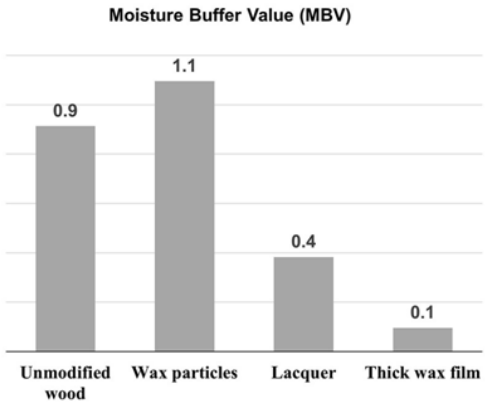


Figure 1. Influence of coatings on water vapor transport and liquid water penetration

To produce these particles, we used natural wax and it was dispersed in water using high mechanical shear. The resulting dispersion was then applied onto the wooden surface and water removed by evaporation at room temperature. To finish the application process, the wood was polished with a cotton cloth. Our assumption was that these wax particles do not form a continuous film on wooden surface, and therefore allow for water vapour adsorption and desorption.

But how can we possibly test the effect of various coatings on the moisture buffering properties of wood? In order to do that, we need to replicate humidity changes in a living space. In this work it was done by using a climatic chamber, where the humidity level can be set and monitored precisely. Relative humidity was set to 75% for 8 hours, simulating a "wet period" that happens during the night, and then to 33% for 16 hours, simulating a daytime-like "dry period". For this experiment, some wood samples were left unmodified, some were coated with wax particles, some with lacquer, and some with a continuous wax film (the same wax as was used to produce the wax particles). The wooden samples were placed inside the chamber and their mass was monitored. During the experiment we were able to see clearly that the mass of the samples coated with a continuous wax film or lacquer was not changing in the same way as the mass of the samples coated with wax particles.

After placing the wooden samples inside the cabinet and monitoring their mass, we could calculate their Moisture Buffer Value (MBV). The MBV shows how much moisture is adsorbed and released by a material when the humidity of the surrounding air is changing. Logically, the more moisture that is exchanged, the better the moisture buffering performance and the higher MBV. In Figure 2 Moisture Buffer Values for the wood coatings tested are shown together with an unmodified wood sample as a reference. As can be seen from Figure 2, the coatings that form a continuous film (lacquer and wax film), decrease the moisture buffering performance of wood. MBV was halved by applying lacquer and decreased even further when coated with a wax film.



Moisture Buffer Value	Level of buffering
MBV>2	Excellent
1<MBV<2	Good
0.5<MBV<1	Moderate
0.2<MBV<0.5	Limited
0<MBV<0.2	Negligible

Figure 2. Effect of coating on Moisture Buffer Value of wood

As can be seen in Figure 2, coating with wax particles did not just preserve the moisture buffering ability, but it actually enhanced it. This means that more water vapour is being transported through and being stored inside the wooden surface; therefore, by applying wax particles we even managed to slightly increase the passive climate control ability of wood. But what about protection from splashes of water? Did the affinity towards water change after this treatment as well? To answer these questions, we studied the wetting properties of the coated surface; the results are presented and discussed below.

As we mentioned earlier, the lower the affinity toward water a surface has, the more hydrophobic and less wettable it is. To assess the wetting properties of surfaces, we deposited small water droplets onto the coated and uncoated wood and analysed the shape of the droplets. The Contact angle is the angle between a water droplet and the surface at the point of contact and it is a numerical representation of wettability. The angles for unmodified and coated wood can be seen in Figure 3, as well as a schematic drawing for the contact angle technique.

We can see that the contact angle is increased after the modification, which means higher hydrophobicity and slower wetting. Thus, liquids can easily be wiped off from such modified wooden surfaces before they penetrate deeply into the structure. The coating, therefore, makes wood easier to maintain and to care for, while preserving the innate moisture buffering potential of wooden material.

In summary, our work provides a sustainable and environmentally-friendly method to reduce the sensitivity of wooden surfaces to liquid water, while preserving their natural ability to act as a passive climate control by absorbing, storing and releasing moisture from the surrounding air. With this treatment, we can use more wood in new areas inside our homes, which helps in making our living spaces more energy efficient but also more comfortable.

More information about this work can be found from our recently published full-text article:

Lozhechnikova, A., Vahtikari K., Hughes, M., Österberg, M. Toward energy efficiency through an optimized use of wood: the development of natural hydrophobic coatings that retain moisture-buffering ability. Energy and buildings, 105(2015), 37-42.

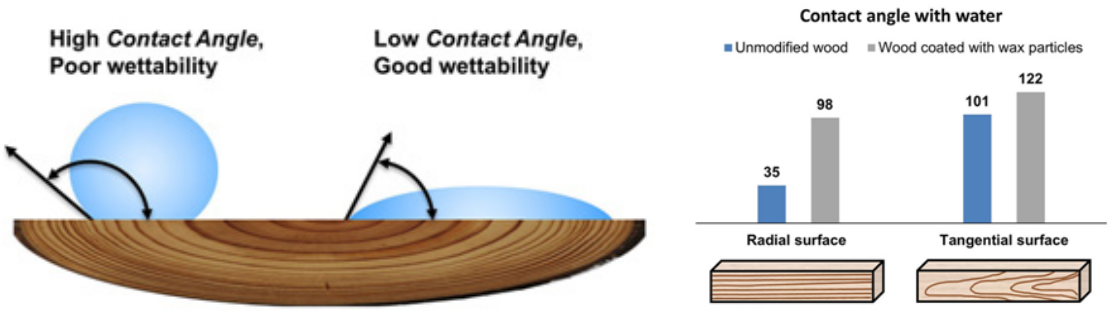


Figure 3. Effect of the coating on water contact angle (after 20 seconds of contact)

Touch Wood

2

Branch Accessories

Liisa Poskiparta

The Branch accessories are made for bathrooms, spas and fixed cabins in different spaces. The bent pieces can be assembled vertically, horizontally or at an angle depending on the use, from a handrail to a towel rail or a handle.

The series has a neutral look and the accessories bring sophistication and warmth to the space and furniture where they are used. The minimalistic appearance enables the accessory family to be developed to cover more specific areas in bathrooms.

The Branch accessories are made from turned ash, suitable for wet spaces. Steam bending has been used on curved pieces.

The series consists of:

Long rail / handle

Door or cabin handle / long towel knob

Toilet paper holder / long towel knob

Short towel knob

Nail brush and pumice stone

Stratum Bath Accessories Collection

Laura Maldonado Guisado

Stratum is a 100% handcrafted collection of Finnish birch plywood objects that bring the look of nature and rustic charm to any bathroom space. They are designed to create a safer and more convenient bathing environment and to make mobility issues or visual impairments easier to live with.

Knock on Finnish wood! The material of Finnish birch plywood is characterized by its excellent strength, sturdiness and resistance to warping. Apart from its beauty, this particular material was chosen because it has a high planar shear strength and impact resistance. These characteristics make it especially suitable for continuous human use. This birch plywood also has excellent surface hardness as well as damage and wear resistance. In addition, it has been finely sanded, giving every piece a smooth and durable surface.

Stratum has a beautiful and lively visual appearance and it is shaped to take advantage of the material´s potential. From the first moment of the creative process, water has been present. Each piece takes us on the trip a drop of water takes as it falls into a pool, creating circular ripples. This connection with nature is present in the wood. Thanks also to the properly surfaced and edge sealed material, birch plywood offers excellent weather and moisture resistance for humid spaces.

The Stratum bath accessories collection makes a huge difference to any bathroom routine.

Stratum is a bathing accessories collection, which interprets the recording of relief or terrain, the three-dimensional quality of the surface and the identification of specific landforms.

They are 100% handcrafted Finnish birch plywood objects that bring the look of nature and rustic charm to any bathroom space.

The collection has a beautiful and lively visual appearance and it is shaped to take advantage of the material´s potential. From the first moment of the creative process, water has been present. Each piece takes us on the trip a drop of water takes as it falls into a pool, creating circular ripples.

Stratum complete collection

Body massager

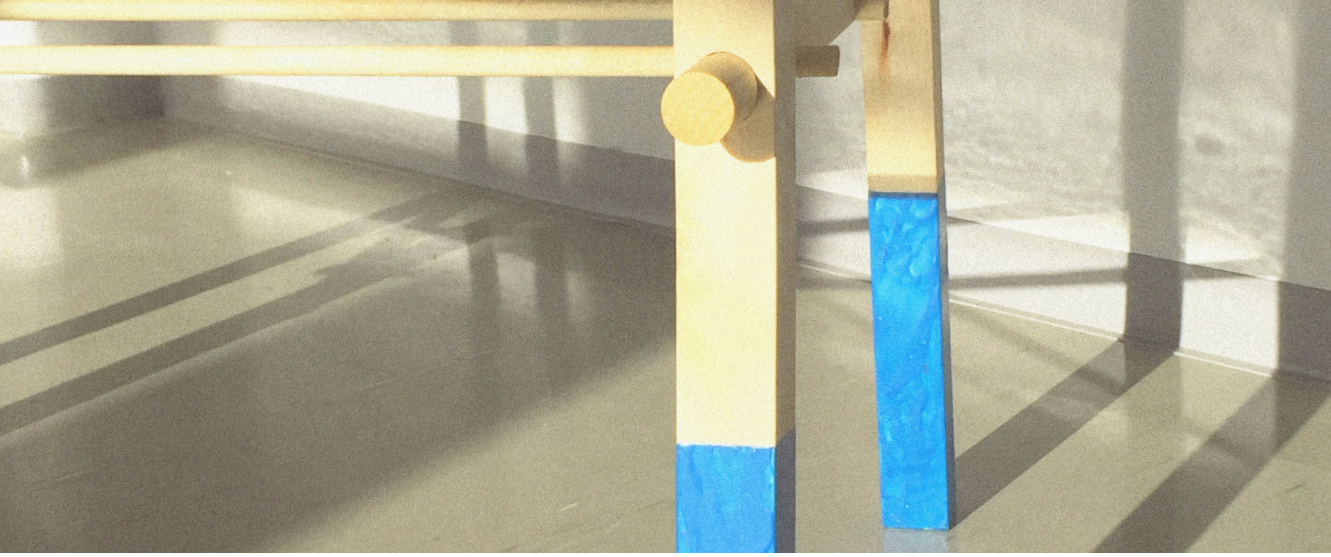
Aroma Theraphy Pots

Orcum Erdem

Aroma therapy plants are surely an irreplaceable part of whole spa experience. Their comforting and healing effects have been traditionally used for ages in many different ways. Considering this, I designed spa pots which allow people to enjoy freshly cut herbs during their bath sessions, as well as a complementary decorative object for spa environments.

As exploration and innovation were fundamental parts of the wood studio course, I decided to test the boundaries of veneers, steam bending and the flexibility of different types of woods. Artefacts were formed from pine veneer strips and the process of constructing them as a vertical closed 3D geometry was the biggest challenge of the project I had to face. Creating a rigid body which can be durable in wet environments such spas and saunas, required new innovations at every step. Besides, after mastering the process, I explored different patterns and ways of construction.

The pine body concentrates the branches of aromatherapy plants and the moisture in the environment or sprinkled water works as an agent, activating sensational odours spreading them across the room. Thanks to its hanging detail, it can be used it as a basket to go and collect fresh herbs and use them directly by hanging it in their shower or sauna.



Naku-uinti

Stephanie A Jazmines

Any consistent tutelage on the properties of wood usually lead to similar conclusions regarding the use of the notoriously porous, "living" material: keep it dry.

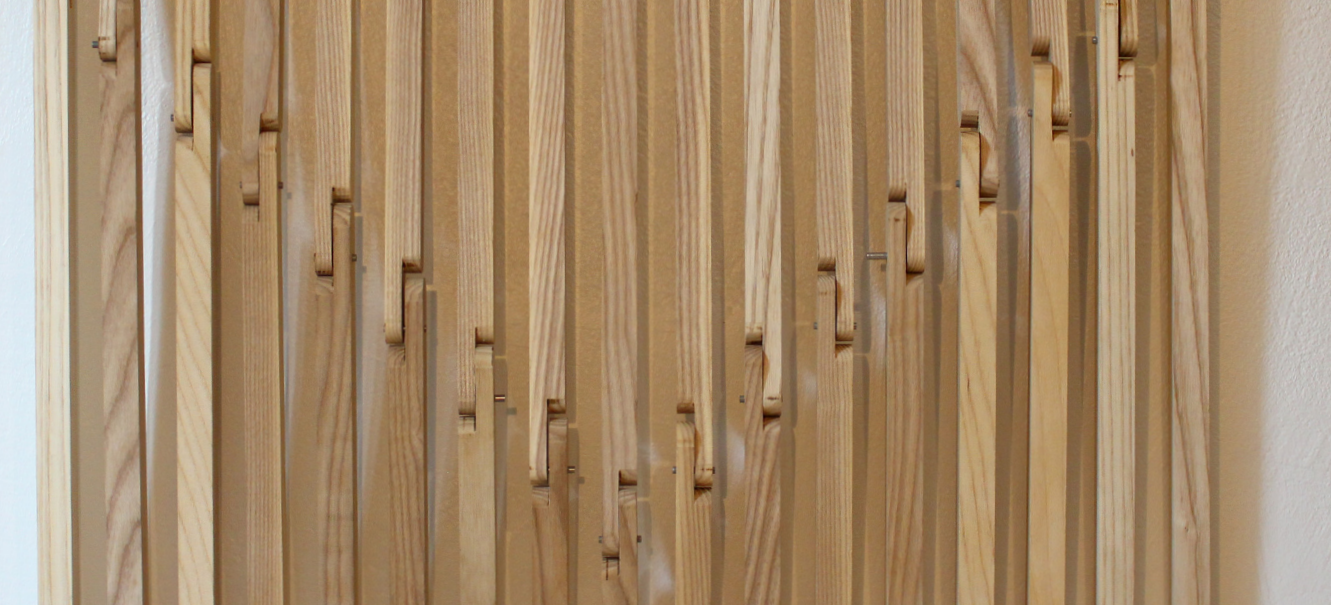
However, when one designs a wooden object intended for a wet space, acknowledging the material's vulnerabilities, as well as its strengths, can provide an approach that is simultaneously aesthetic and didactic. Aspen, or Haapa, was chosen as an appropriate species because of its nearly white appearance, as well as its traditional use in both exterior cladding and sauna interiors. The intention of making a towel rack that also provided light was to explore this same dialectic of the multiple usability that aspen offers. Being a rather stable species, the dimensions of the wood members were kept quite skinny and long, giving the piece a slenderness that still allows the shelves to be supported above.

The piece is finished in parafin oil to provide a layer of protection overall while still maintaining a natural appearance, keeping the wood quite bright. However, as the end grain of the legs in is constant contact with the floor, this is the most susceptible to water damage. For this reason, they are dipped into a rubberized, protective coating whose texture and colour indicates its intended purpose. Being a flexible, durable material, the rubber coating can move and swell as necessary while also grounding the object visually. The colour itself becomes a very obvious reference to the water it is resisting.

The actual construction of the towel rack is meant to be as simple as possible. Every piece is a straight, extruded profile that exits the piece in the same way that it enters it. The joint, then, is not glued allowing the moisture and wood expansion to tighten the connection.

The light is an LED strip embedded into a single channel on the uppermost dowel. However, as the piece is anchored in trapezoidal pieces on either end, it lends itself to flexibility on which way the light faces. The shelves make reflected, indirect light optimal.

The name "Naku-uinti", Finnish for "skinny-dipping," is meant to communicate the physical appearance of the piece while also calling to mind the wet spaces for which it was designed.



Front surface

Rhythmic Hanger

Ye Jun Kim

This rhythmic hanger is made of ash wood, connecting hinged stick units 700mm length. It is basically a foldable hinged hanger for use in a wet space.

The design comes from the idea of using a product in a compact space. The hanger can be put on the wall flat, but when pulling down the edge, it makes a beautiful curved shape with hinges which can be used for hanging. The design aims to offer a classical wooden hinge joint. This waving shape gives the user the ability to transform the interior space through transforming the surface. In addition, the product can be changed by rearranging the units themselves.

Ash wood has been used as a whole. It is a hard and heavy hardwood, used a lot in furniture making. The most characteristic aspect that it has been chosen for is its beautiful, prominent, wood grain, which makes the space more luxurious and softer. Also, it has very good overall strength properties and excellent shock resistance so it is a perfect material from which to make a flexible hanger.

The working process must be calculated in advance so that every hinged point can be fitted to exactly the right dimensions. The most difficult shaping process was making the half-circular shape on the edge as one piece. The work needed to be delicate to make the edges smooth.

Rhythmic Hanger in a wet space proposes minimal use in a compact space that can be folded away when it is not in use. In addition, by making it with wood, it shows natural beauty itself.

The process of making the Rhythmic Hanger started with accurate measurement to reduce the tolerances when assembling each of the sticks in the end. The semi-circular shape was ground with a machine until the shape became close to circular. It was a challenging part to make the boundaries smooth by hand, keeping the same shape in all the units.

There is a difference of 50mm in each of the hinges so that when it is folded, 50mm points come out which can be used for hanging. All the units are connected with 5mm metal through the holes. The edge holds the metal pins and enable it to move vertically. The hinges are also made rounded, which makes it possible to stop at a certain point automatically without any devices. The edges are slightly sloped so that it helps to fold more easily from the top.

Hinge detail

Folded view

Duo Coat Rack

Hanna Särökaari

Duo is a modern and simplistic interpretation of a traditional coat rack. It consist of two parts that you can use for the base according to your needs. Longer garments can be hung on the upper part and smaller ones on the lower part. The idea of the Duo is that it can also be used as a towel rack. It fits in public spaces as well as in the home environment.

Duo measures 180 cm × 60 cm × 35 cm and it is made out of oak. The black finish is created by burning the surface, and wood oil gives it a slight gloss and protects it. Burning and oiling the wood makes it withstand water, so the Duo coat rack can also be used in humid spaces, such as saunas and locker rooms.

I wanted to create an artistic piece that has sculpture like characteristics, without sacrificing usability. I also aimed for simple design and clean lines.

Kumiki Mat

Sei Yoshikawa

This is a bath mat for wet spaces. The wood material is elm and the width is 680mm, the length 440mm and the thickness 20mm.

It looks as if it was knitted like a fabric, but the material is wood. The wooden sticks are connected through a simple wooden components with unique joints allowing them to stay together even without the use of nails or glue. Each pieces has some hollows and they are put together like a puzzle. It is a little difficult to join them all up completely.

This joint system is named Chidori. Chidori is a very traditional way in Japan to connect wooden pieces. The name of Chidori comes from an old Japanese toy in Hida Takayama, a small town in Japan. It is better for wooden products in wet spaces if they are made only of wood materials because there are cases when points connected by glue or by other things are not strong enough when in contact with water. Therefore, I used the Chidori joint system for the bath mat.

I used elm because it is a hard wood. I had to cut the materials accurately and it is very delicate work. When I made the mock-up in pine, it cracked. So elm was a good choice for my product.

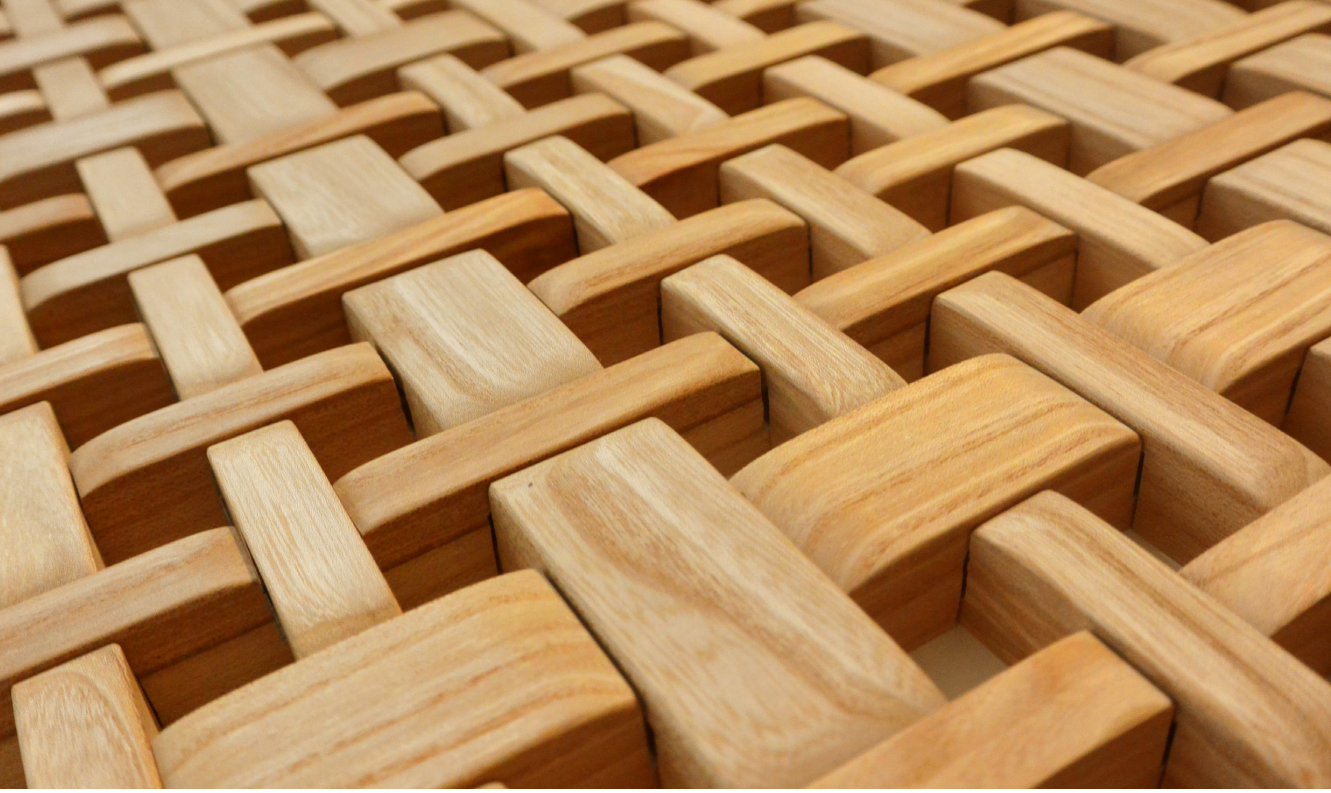
I also designed the pattern. I used materials of two widths, one being twice width of the other. I tried to give rhythm to the design of the mat by doing so. Moreover, the surface of the mat is curved, to give a better feeling underfoot when we use it.

I am very satisfied with this work. This was the first work made by myself, so it was hard for me, and I spent a lot of time doing so.

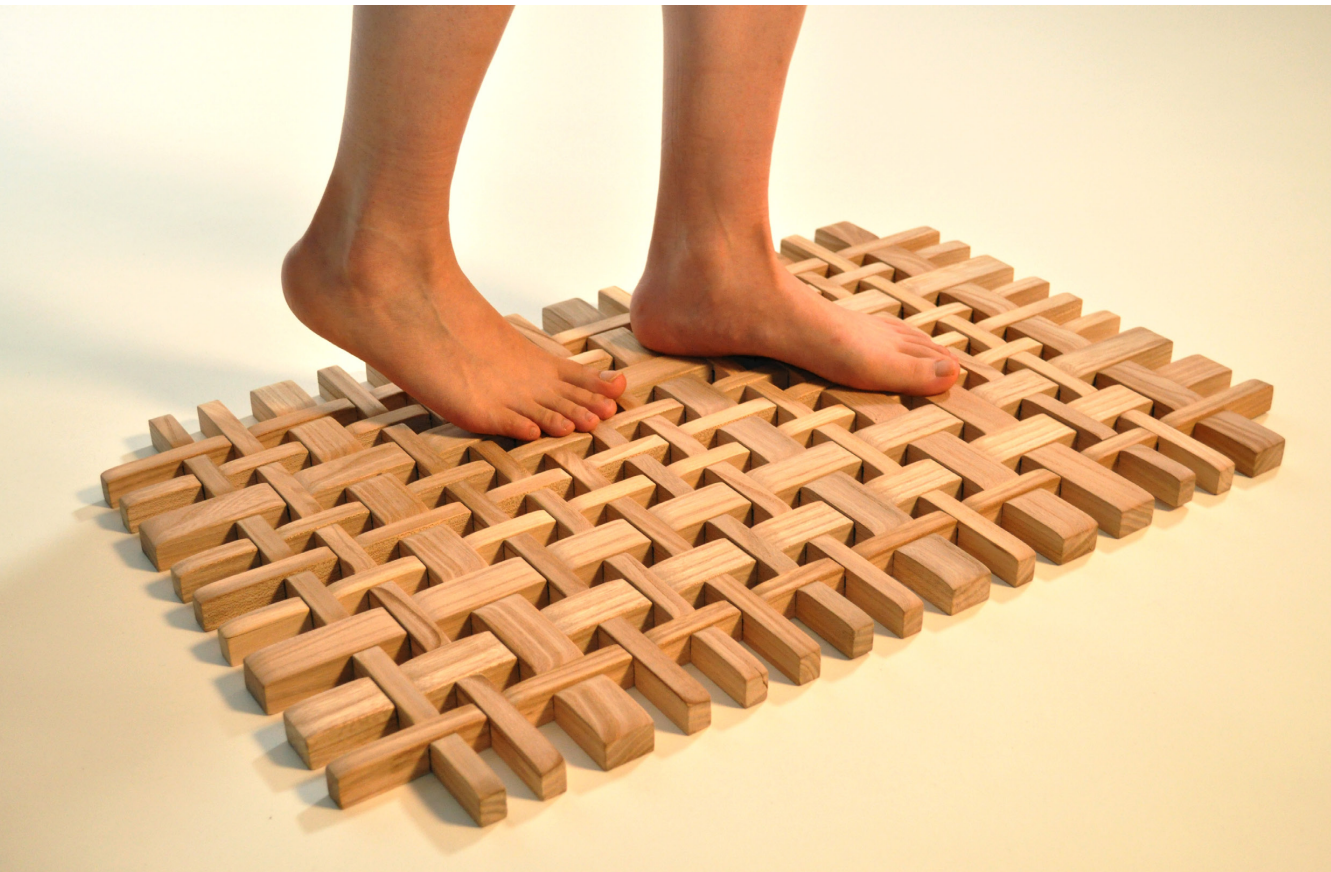
First, the sticks of two widths and two lengths were made. Hollows were cut in each piece to the same depth at the fixing places. Then, the edges of the sticks were shaved and their surfaces were curved. Finally, all the pieces were put together.

The most difficult point was to joint all pieces. If the places of the hollows were just a little different from other pieces, they couldn't be connected. So the places of the hollows were important and cutting them was very delicate work.

Before I designed this mat, I didn't know about this way of production. Through the wood studio, I not only learnt about the wood material and how to make the product, but also the traditional techniques of my home country.



Surface detail



Taipuu floor made of larch

Taipuu

Vilde Rapp Riise

The task was to explore the use of wood in wet spaces. Houses as we know them have wooden floors in every room, except the bathroom. Water, moisture and wood can often turn into something unpredictable. The wood moves and cracks and bends. This is something we can't control. So why not take this disadvantage to our advantage? In a bathroom the floor is always exposed to water, whether it is next to the shower, under the toilet or in the shower.

The floor, Taipuu (Finnish; it bends) was developed in collaboration with a physiotherapist. Over time, the floor will bend even more, as a result of the already curved surface. After doing a lot of experiments the best wood to use for my project was larch. Larch is used because of its unique qualities considering moisture, fungi and how much it bends, which was an important factor for me. To force the bending and to take advantage of this, I made a slot underneath. The top of the floor will be in direct contact with water, the water then flows through the gap and turns into moisture that will affect the bottom side of the floor. This way the floor will bend even more.

These changes will happen day-by-day, which is good for your balance, blood circulation and stability in the hips and back.

Taipuu is about two square meters in size. It consists of 10 pieces of larch. The width of each piece is between 115 mm and 125 mm. Water can flow freely in between the gaps. The gap is 4 mm wide.

The already curved surface will help the floor to bend even more. The curve is carefully calculated to be the most comfortable to walk on. Also considering the benefits of walking on an uneven surface.

The connection with rope allows the wood to move, shrink and expand. It is connected in three different rows underneath the floor. On top of the floor it becomes a nice detail, and also gives a hint of the visible construction.

Connections with rope

The floor is connected with three rows of rope

Bucket Stool is inspired by asian public bath culture

Bucket Stool

Yu-Hao Shen

Bucket Stool is a portable wooden product design for wet space. It is inspired by Japanese public bath culture in Taiwan. We usually carry our bath towel, shower gel, and shampoo in a wooden bucket or plastic basin there. And we also sit on a bath stool to take a shower before we take a bath. So I finally came up with an idea which is about combining those two cultural behaviours in one object. This design can make our process of going a public bath more convenient and is also a way to present our culture.

In the details of this design, Oregon pine, which is famous for the material of Scandinavian boats, is the main material. I used the technology of lamination to build the round shape. I tried to keep the traditional bucket shape and also simplify it. The part of the handle is not only a hint at portability but can also strengthen the structure when it is used as a stool. The size is similar to a normal bath stool. It is really nice for carrying and for sitting on.

Bucket Stool is a portable wooden product design inspired by Japanese public baths in Taiwan. It can carry people's items to the public bath and become a bath stool when the user is taking a shower.

Carry your items to public bath

Sit on your stool and take shower

Assembly

Wright Stool

Henry Daly

The Wright Stool is made from white oak and stainless steel, it is 400mm in height and 340mm in diameter.

The design is inspired by the craft of the Wheelwright; fitting steel tyres to wooden wheels for carriages and wagons. Heating the steel increases the diameter of the band making it bigger than the wooden wheel. The tyre is hammered into place on the wood and cooled immediately with water shrinking the band and compressing the spokes into the hub. No glue is used and when the wheel is exposed to moisture during use the spokes expand and the joints tighten.

Designing a product for a wet environment is an opportunity to use a joint that gets stronger with an increase in moisture. The expansion of wood in the presence of water is normally a negative material property but in this case it is used as a positive.

The process must be designed so that within the short assembly time the band seats itself in the right place and the legs hold their position. The band is difficult to handle once heated and will be damaged if hammered due to the temperature and its thickness.

Heating the steel causes a permanent change in the colour that complements the oak around it. Burn marks and blemishes on the steel are not removed so that the final appearance of the stool reflects the way it was made. The oak is left unfinished so that the stool can develop a natural patina over time that tells the story of its life.

The start of the process is slow and precise where the oak parts are accurately constructed and the top is turned with a constant diameter across its thickness. The stainless steel band is rolled and welded to a slightly smaller diameter than the wood. This dimension is worked out using the circumference of the wooden top and the equation for linear thermal expansion.

The assembly takes place in about 10 seconds. The band is heated to 700 degrees C, the wooden assembly is hammered into the band and immediately cooled with water. The band contracts to its original diameter and compresses the legs into their slots forming a very strong joint. Once the band has cooled it cannot be moved or adjusted. This unforgiving process gives the maker a strong sense of satisfaction when the stool is assembled correctly.

Band patina

Wright Stool

Birch Bark Bench

Maarit Peräsuo

Birch bark is a strong and water resistant cardboard-like material which has long history in Finland as a valuable building material and in crafts. It has been used in the same way as fabrics and leather because it is easy to cut, bend and sew. The material has inspired me since I have been child and I wanted to research whether this beautiful 100% natural material can be used as a part of furniture.

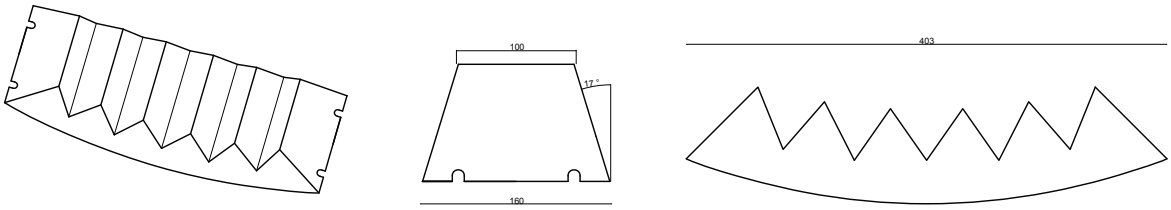
Bench is handmade and all parts are made round and smooth to highlight the material's flexibility. The round design makes weaving of the birch bark easy and keeps it whole even when the tape is moving along the bench series. Traditional direct-paned weaving is used as a seat for the bench. The pattern of the material is strong and natural and it suits the wooden birch parts well.

Birch bark Bench is a good result of research in to the material durability. It is 100 % natural and tapes are easily renewed if needed. Birch bark gives a strong expression for the bench. The material also has a sensitive surface and feels good against the skin.

Wooden bench made from birch and the seat is woven from 1 mm thick and 50 mm wide birch bark tape. The size of the bench is 1200 mm * 400 mm * 450 mm.

The birch bark is cut in a spring when it has better qualities and it is easier to remove from the tree. Cutting has to be done lengthwise because the material lasts better in the direction of the fibre.

Birch bark is thinned so that it has same thickness all over which makes weaving easier. Lengthening birch bark tape is made by creating a sloping cut and strong contact clue. Traditional direct-paned weaving is fastened to the bench with rivets and glue. Finished furniture is coated with oil to keep it clean.



Line drawings "Swing your ass off !"

Swing Your Ass Off !

Heidi M. Huovinen

Swing your ass off! - "Hot for your butt believe it or not!"

Ash tree, 400 mm x 160 mm x 100 mm

The design of the swing is inspired by jewellery from different cultures from around the world and the wellness factors of a needle mat. As the needle mat is designed to stimulate larger areas of the body the swing is designed to concentrate only on your butt!

The shape of the swing is designed to resemble a necklace hanging from the ceiling. The wooden piece lies on top of two thin plastic cables which are held in place on both sides of the wooden swing seat.

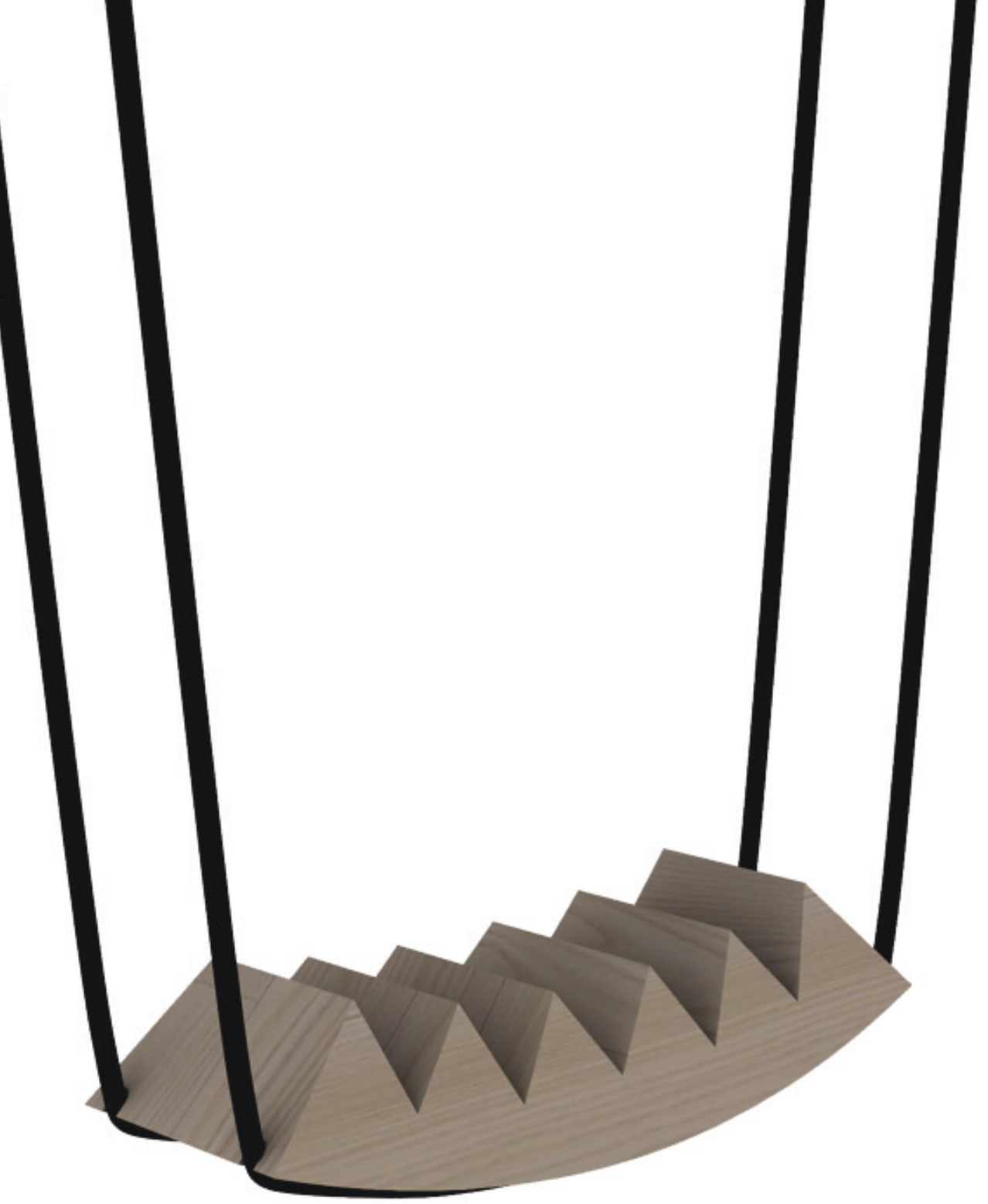
Concentrating on wellbeing, the design of the seat adds a different experience to swinging. The spikes of the seat stimulate the bottom and the movement of swinging intensify that feeling.

The wood´s surface is left untouched to bring out the beautiful colour of the ash tree as well as to resemble the wooden jewellery behind the inspiration of the swing.

The process of Swing your ass off! was inspiration oriented. Finding the balance between the delicate qualities of jewellery and wellbeing was the hub of the swing design.

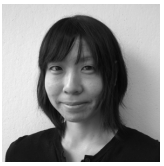
Somewhat painful looking jewellery such as neck rings and lip-plates worn in a few African and Asian cultures gave the idea for creating a jewellery-like swing with a twist; by reminding the user constantly of the surface underneath him and by being aware of the feeling of stimulation.

Sitting on top of a stimulating surface is an interesting study case. Adding movement to this experience is also in the control of the user of the swing.



Rendering "Swing your ass off !"






Cube Sauna Bench

Lahti Toni
Morris Christopher
Nakamura Tomoyo
Noh Taeho

The CUBE Sauna Bench concept takes the idea of a "melting cube" and applies it to an ergonomic sauna bench for comfort and ease in a Finnish cultural institution. With the need for a gentle feeling and interest in textural irregularity, the bench is easily manufactured and added together, while still structurally sound and easily replaced when needed. The situation in which the CUBE is to be applied is that of a public sauna - ideally for five days per week for eight hours a day at 80 to 100 degrees centigrade with +90 percent humidity. A drying/cooling cycle of 16 hours at 25 degrees/60 percent humidity accompanies the schedule of the bench. The lattice structure underneath the cubes, which interlock at the lattice joints on top, is replicated through a series of cuts with precise measurements to ensure a 90 angle and comfortable fit for the cubes. The cubes are made in four steps, with the later stages being fit through a guide for ease and efficiency. The species used, in this case aspen, was determined through a series of tests with other species and grain directions. Coating tests and durability tests were also performed in terms of maximum public sauna usage.The goal of designing a new type of a sauna bench was to overcome the conventional appearance which can be easily seen anywhere. For this reason, block-type seating was suggested and an idea to solve the structural part of the seating was needed. A sauna bench with an elegant, curved surface has a sense of inviting users to sit on through sheer aesthetic appeal and interest. Wooden blocks nicely shaped into the shape of ice-cube give people a unique haptic experience, a goal of making sauna the best experience possible.

ABSTRACT

Tactile and ergonomic sauna bench made for public saunas through mass production

TECHNICAL INFORMATION

Species: Aspen (Haapa)

Structure: Lattice

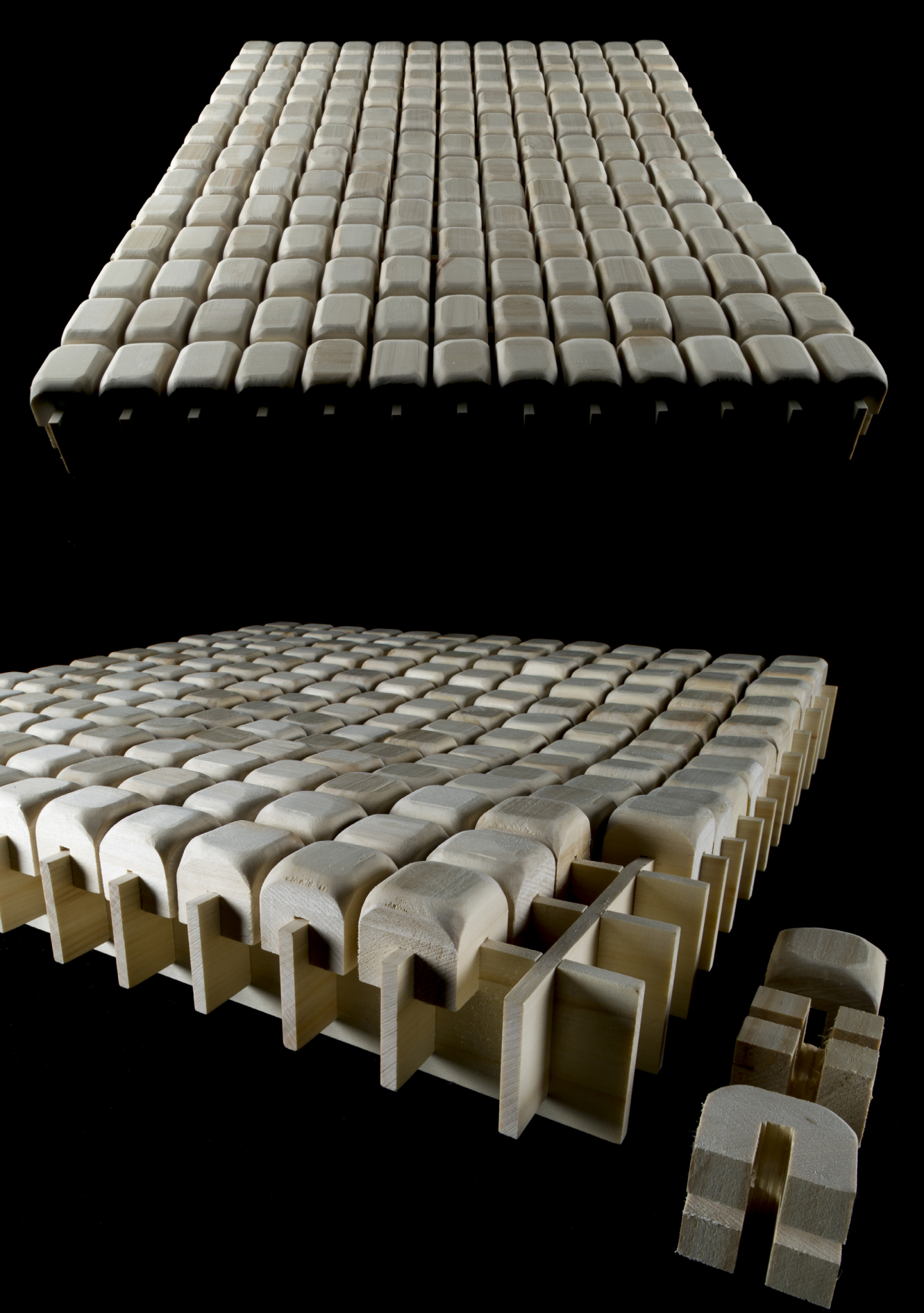
Cube dimensions: 40x40x40 mm with a gap distance of 5 mm between

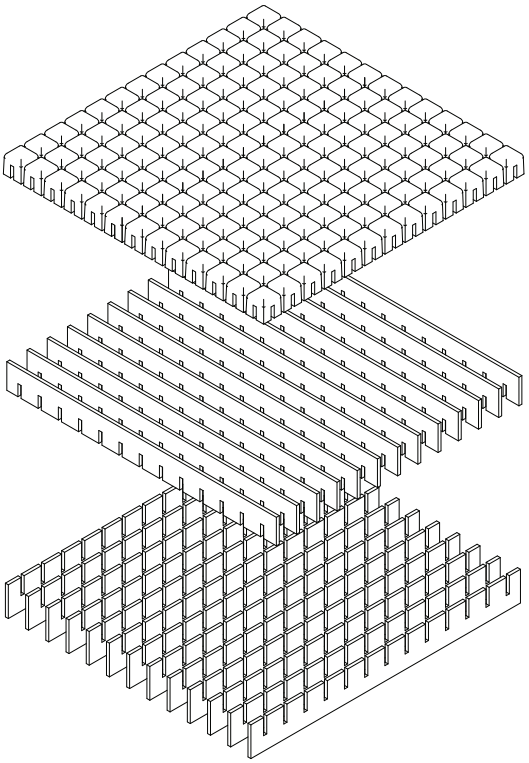
Structural dimensions: 600x65/55x6.7mm

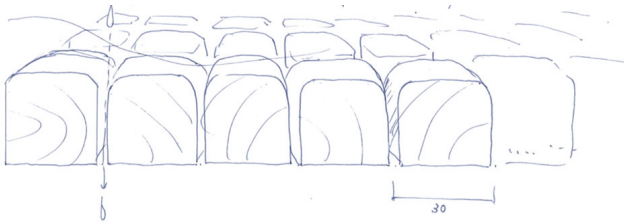
Testing methods: High temperature, high humidity in a cycle of eight hours on, 16 hours off at room temperature

Treatments: None

Joints: With wooden mechanics only



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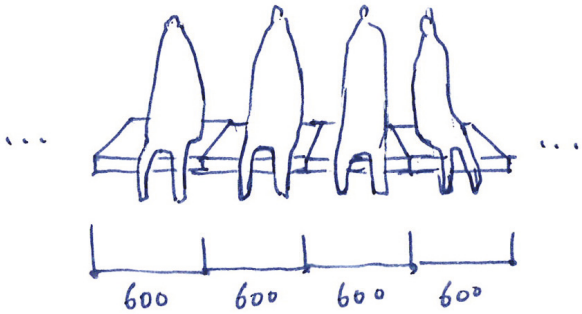
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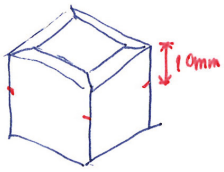

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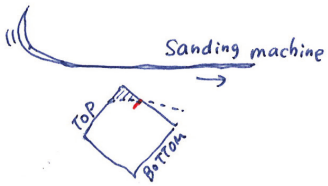
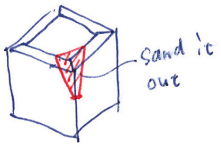
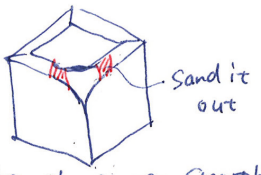


2. Round a corner to mark





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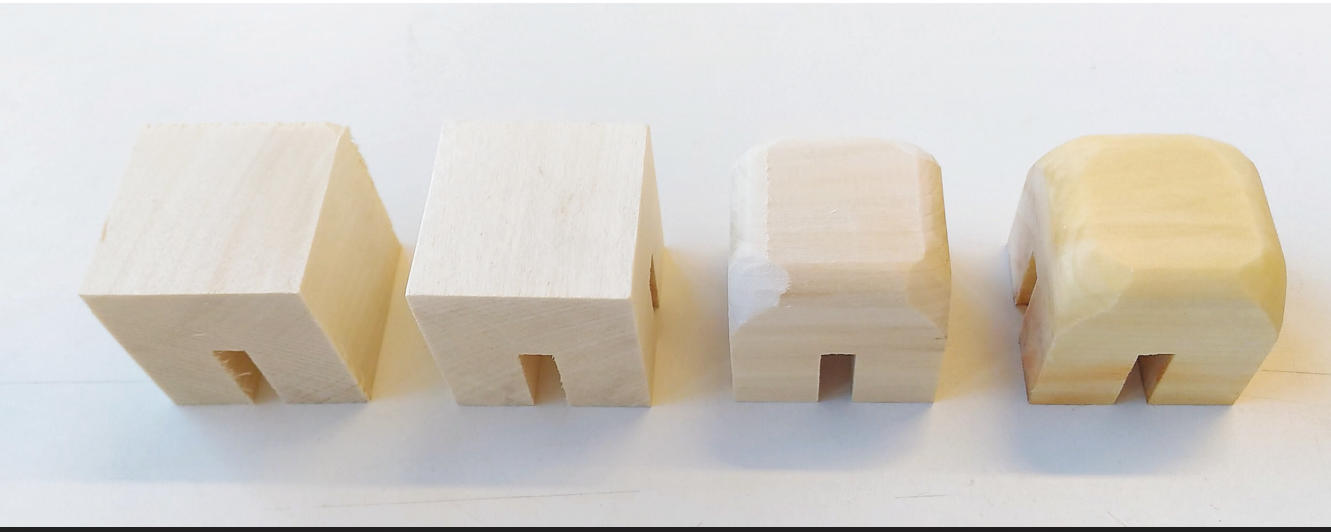

Use of Wood in Elderly Care

Ira Verma

Ira Verma
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Universal Design principles aim at the development of products and environments that can be used by all people, to the greatest extent possible. One approach to universal design is to use people with physical or sensory impairment as "lead users". The lead user method is utilized to develop innovative products by solving a particularly demanding challenge. The end result is aesthetic and improves the experience of all users. The universal design of bathrooms emphasizes accessibility, wellness and the prevention of accidents. The principles include the notion of equitable use, flexibility, simple and intuitive use, perception, error tolerance, low physical effort and space for approach and use. These principles can lead to the innovative product development of wooden objects.

AGING

The student works described in previous pages raise ideas about the use of wood material in the care of frail, elderly, persons. The proportion of very old persons is expected to increase rapidly in the coming years. More than 90 per cent of persons aged 75 years and over are able to live in their own homes. Almost 80 percent of them live in owner-occupied apartments. Less than half live in apartment buildings and the majority live in single family homes, semi-detached or row houses and are not willing to move. However, the person-environment fit changes with age. Hearing, vision and physical function may decline. Home alterations can help to partly compensate for the loss of sensory function or physical impairments. Most falls occur in the home environment and immediate surroundings.

In particular, the number of frail elderly persons over 85 years is growing fast. The probability of having Alzheimer's disease or other cognitive impairment rises in old age. Alzheimer's is the most common form of dementia which affects how people cope in daily life. In Finland, it is estimated that one third of persons over 85 years suffer from cognitive impairment. Home modification can help a person with Alzheimer's cope with the Basic Activities of Daily Living (BADL), like bathing. According to a previous study, home modification has been shown to provide positive outcomes for a person with Alzheimer's and, moreover, relieved the stress levels of the caregiver too. Simple modifications like water temperature regulation, non-slip floor materials, grab bars and shower seats improve safety. In the later-stages of a progressive disease the person needs extensive help with daily activities and may need to move to a care home with 24 hour care.

Spaces are experienced with all our senses - vision, touch, hearing and odor. Elderly persons with cognitive impairment are especially sensitive to temperature and to the acoustic conditions in a bathroom environment. Bathing also means functioning in an environment that can be slippery when wet, and many falls occur in the bathroom. Bathing is a stressful situation for elderly who are not able to wash themselves without assistance. It is also the most challenging situation for the caregiver. Physical conditions such as noise, cold, and glare are contributing factors that affect the feeling of comfort. A person with Alzheimer's may find the bathroom uncomfortable and undressing can make them feel vulnerable and embarrassed. The bathroom can be experienced as being cold, running water may sound loud, and there is the fear of falling. The sensory experience may cause discomfort, stress and aggression. Therefore, the visual, tactile and acoustic environment of a bathroom should be designed with attention.

BATHROOM

To assist elderly persons with visual or cognitive impairment in the bathroom, the perception of the space has to be improved. Not all people with visual impairment are able to perceive colors, however, most are able to perceive contrast between dark and light. For example contrast between the toilet seat and the background wall helps in visual perception. In the same way contrasts between the toilet lid and the surroundings

Figure 1. Kustaankartano care home for elderly (Sotera)

Figure 2. Kustaankartano care home for elderly (Sotera)

can help perceive the toilet seat. The provision of proper lighting is essential for the perception of contrast. Contrasting colors and lighting increase independence. Then again, glare and reflections from the wall and floor surfaces can reduce visual perception as well as impairing the acoustics. Persons with Alzheimer's may perceive, for example, the reflection of light on the surface as water. In the same way, a dark spot on the floor can resemble a pit. Therefore, all surfaces should be plain and without big contrasts or patterns. The floors and walls should have non-reflective matt finish.

Safety bars, handrails and shower seats in the bathroom enhance safety and help prevent falls. The existing wall may need reinforcement for the installation of the bars or shower seat. Gypsum board is generally not strong enough to be used as a wall surface material, as greater strength is required for durability and for the fixtures. This would be a potential market for durable timber wall finishes. The installation of safety bars without damaging the water insulation of the floor is also a challenge. A wooden shower element or a wooden wall may help to resolve the problems associated with the installation of the bars and shower seats.

The dimensioning of the bathroom will have to facilitate the construction of the wooden wall. However, the requirements for cleanable interior surfaces in care facilities often places limitations on the use of timber products.

The wooden shower element can also improve the acoustic qualities and reduce the reverberation time in the bathroom. A wooden wall would be aesthetically pleasing and feel warm to the touch. Some challenges remain, however. The surface of the floor has to be even and spaces between wood lamellae on the floor should not exceed 5 millimeters. The surface has to be slip resistant in wet conditions and the shower element has to be level with the floor. Otherwise, a non-slip ramp has to be provided.

A comfortable bath seat is needed for safe bathing. A wooden shower seat is warm and smooth and would be comfortable to sit on. The safest option is a folding seat on the wall. Grab bars or grab rails on the wall can reduce the risk of falling when taking a bath or shower. Wood can easily be used and sculpted for a pleasant hand rail profile. Handles and grab bars should be long enough and have a circular profile from 30 mm to 50 mm

in diameter. The position can be fixed individually and there should be space for the hand between the grab bar and the wall. The texture and shapes of the material is stimulating and therapeutic for the frail elderly. Ergonomic wooden brushes with a round shape provide tactile stimulation and add an aesthetic quality to bathing. In care homes there is also the need for extra space for personal hygiene articles and for toiletries. The personal hygiene articles have to be readily available and within arm's reach and require low physical effort. The ability to reach is reduced for a person sitting in a wheel chair. The design of the coat rack should be such that it can be used from different heights. A person sitting in a wheel chair, or a child, can reach the cloths or toiletries from a coat rack placed at an individual level.

These wooden design objects are pleasant in use for the majority of persons. The overall idea is to design for human diversity and not to produce solutions for a specific group of people. The wooden material is natural and stimulating. It is visually beautiful and can be therapeutic for the frail elderly.

Sense Wood

3

The burning process

Kaski

Saara Kantele

Kaski is a route for water to flow through the burned surface of wooden channels. It's a small scale material study of water, movement and burned wood. At the end of the water path lies a seedling of a tree.

Throughout the process some wood species were tested and aspen, ash and spruce were selected, due to their water compatibility qualities and the different but beautiful types of burned surface they produce. Also various channel shapes were tried out to alter the movement of water.

The surfaces of the channels were burned to a thick charcoal, as a traditional treatment of wood used in wet environments. Usually the surface is brushed after burning to prevent the blackening effect. In this case the channels are not touched, and the moisture keeps the charcoal dust on the surface so that the wet surface doesn't actually give away colour.

Kaski is a detail that can be used as a part of water flow system in spa or sauna environment. The combination of burned wood and wet environment has been traditionally used for example in haapio-boats and pike ends for fences, meant to be stuck into the moist ground. The burned surface endures moisture well and it also has disinfecting qualities utilized here while the water flows though the wood.

"Slash-and-burn (Kaski) is an agricultural technique that involves the cutting and burning of plants in forests or woodlands to create fields."

- Wikipedia

Kaski appeals to all the senses. Wood is a material with a strong character, and the smell of fresh and burned wood is part of the experience. Likewise the movement of water, with the soft, soothing sound, is generally thought to intrigue human senses.

The growth is the last element, the living tiny tree at the end of the water flow. Symbolically it's the circle of life of wood nourishing from the water flow as a renewable source of natural material.

The route of the water drops

When the wall is dry, the leaflets open letting light come through

Living Wall

Henri Judin

Wood is a living material. Especially when it comes to using wood in wet spaces, we usually consider this to be a restrictive feature of the material. I wanted to turn this presumption on its head and make the expansion and contraction of wood into the main quality of the design.

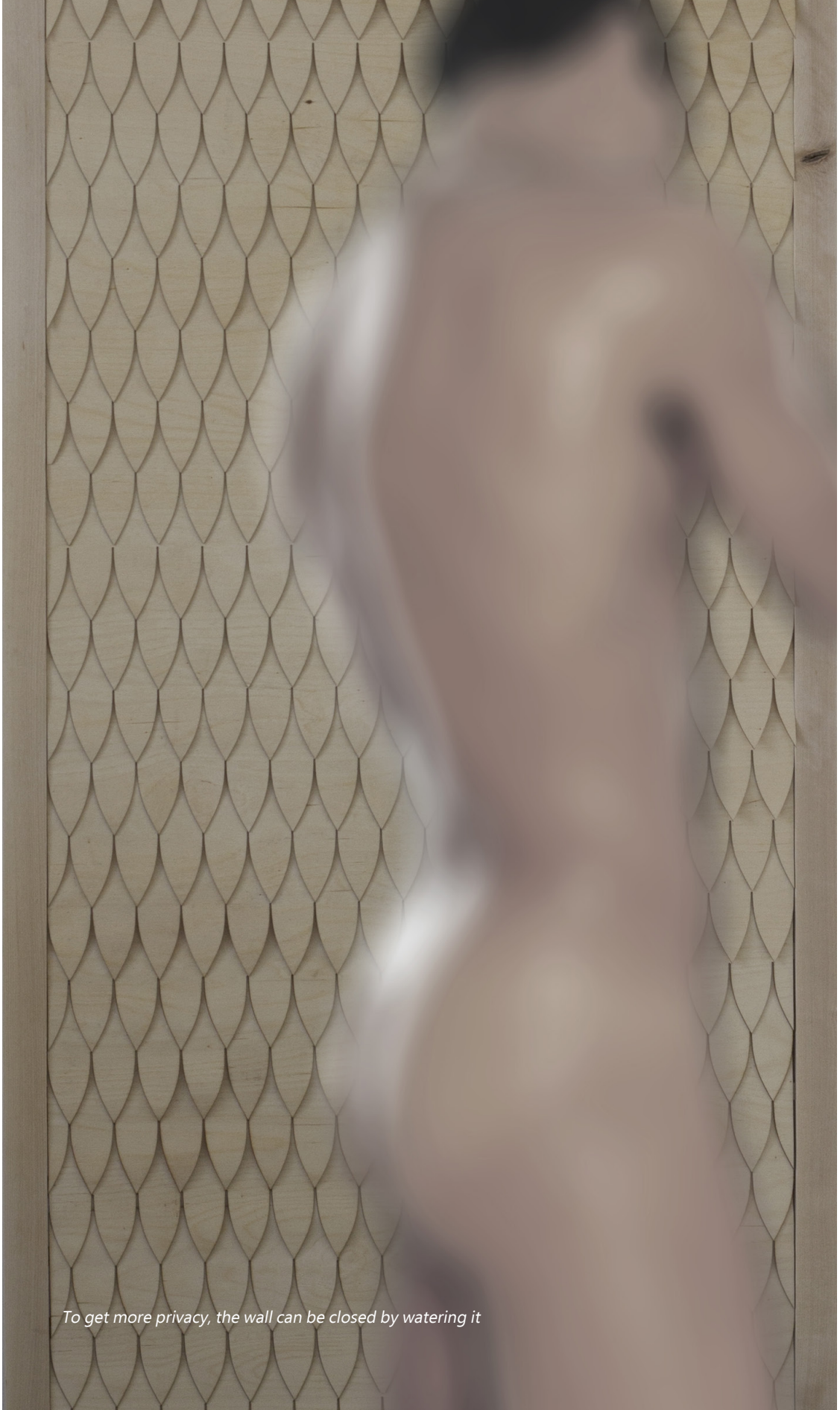
The manufacturing process was a lot about experimenting, trying and taking showers with pieces of wood. When the right material, thickness, and other features were discovered, the results were surprising and the movement of the wood was unexpectedly big and fast.

Living wall makes showering an overall experience: the discreet movement of the leaflets aren't only appealing to the eye, but the scent and the sound of the dehiscent wood create a natural moment, like taking a shower in a spring in the middle of a summery forest.

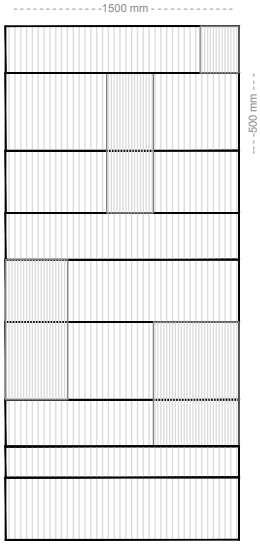
Living wall is a shower wall and a space divider for wet spaces.

The wall consists of thin laser-cut layers of plywood that move according to the moisture content and the use of the space:

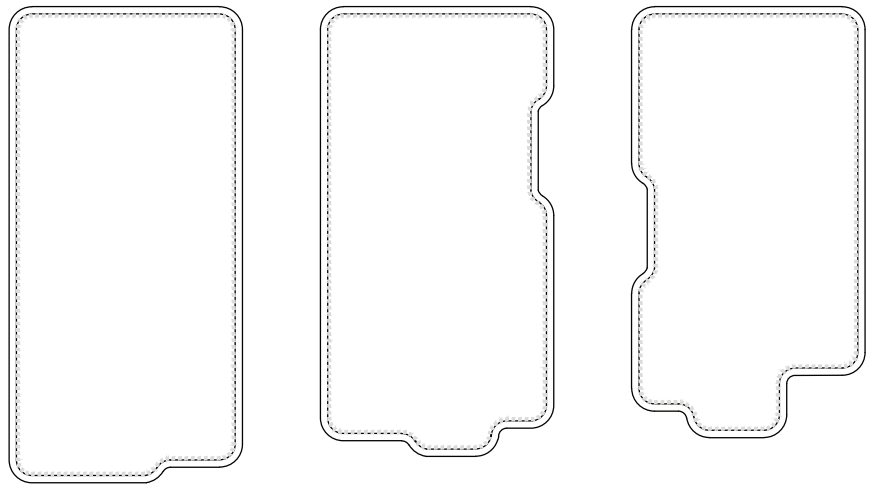
When the space is dry, the leaflets roll up creating a see-through and a light permeable wall. When more privacy or less light is needed, the wall can be closed by watering it.



To get more privacy, the wall can be closed by watering it



Balneum example
Floor plan



Variations in section series: Pine framing and oak slats

Balneum

Annamiia Suominen

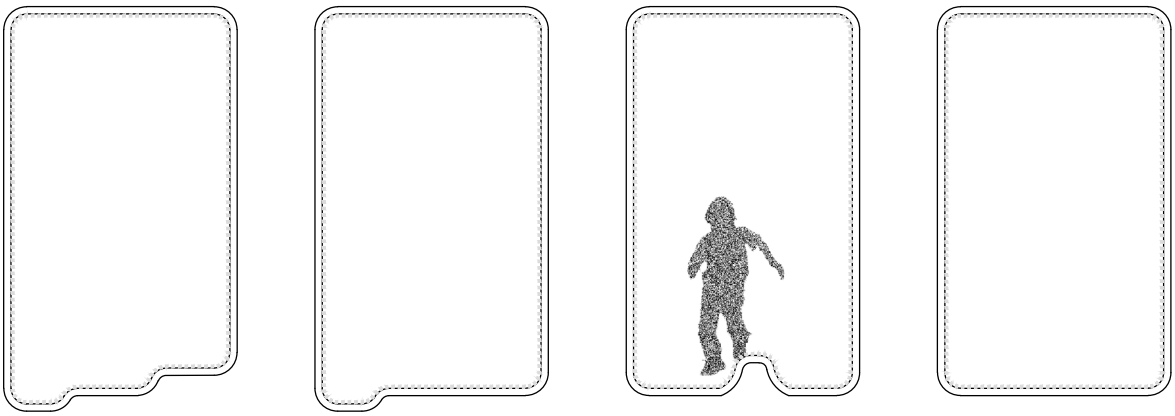
A Wooden Balneum is a breath from ancient Rome and it is brought to the modern era with an approachable sense of wood. In our hectic world it reminds us of the reassuring simplicity and beauty of our everyday facilities for bathing. It erects a place for recreation and cleaning where socializing can play an important role.

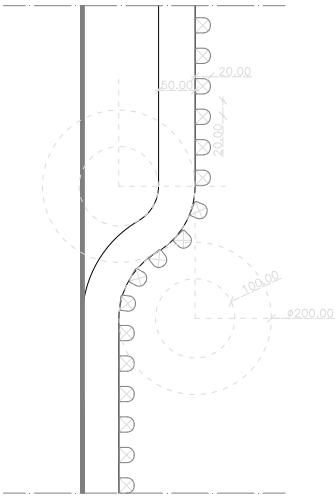
Wooden Balneum is a starting point for designing a wet space. It is a skin that can be altered to different forms of use. It unifies fragments of a space into a coherent whole.

Wooden units are the primary structure, which vertically frame a spa area. The units have varied forms that are set in line with a spacing ranging from 300 to 600 mm. Wooden slats that form a secondary structure face the units with varied distances always from seating surfaces to sparse shelves. The facing always evolves from floors to shower bases and tubs as well as to walls and roofs, likewise to shelves and countertops, and to many other possibilities.

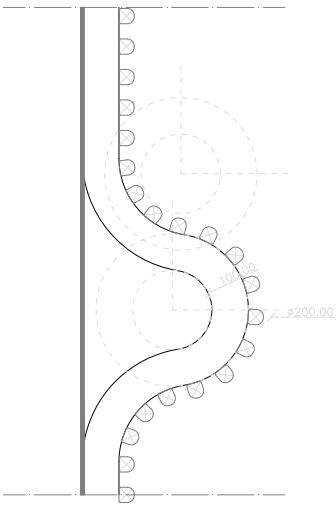
For me a spa is most likely to be a white tiled cold space that feels more like a hospital space or even a morgue. It is an area that doesn´t seem easily approachable and the surroundings are far from homely and comfortable. I tried to find another approach.

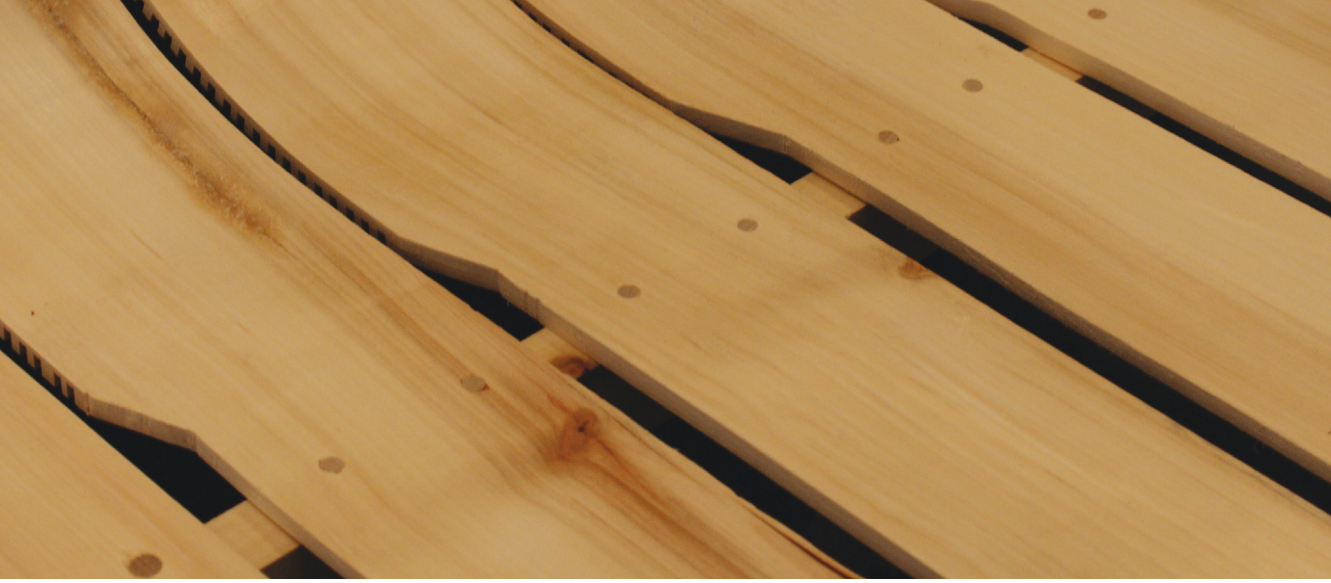
The Balneum is entirely wooden and more precisely the main structure is from pine and the slats are from oak. It has gone through a soap treatment where it has acquired dirt and moisture repellent surfaces. To maintain the light wood colour in the slats a white wood soap would be better in the soap treatment and might be sought after in a spa space. The treatment of soap and fine sanding should be repeated more in the beginning and less frequently later on.





Sections









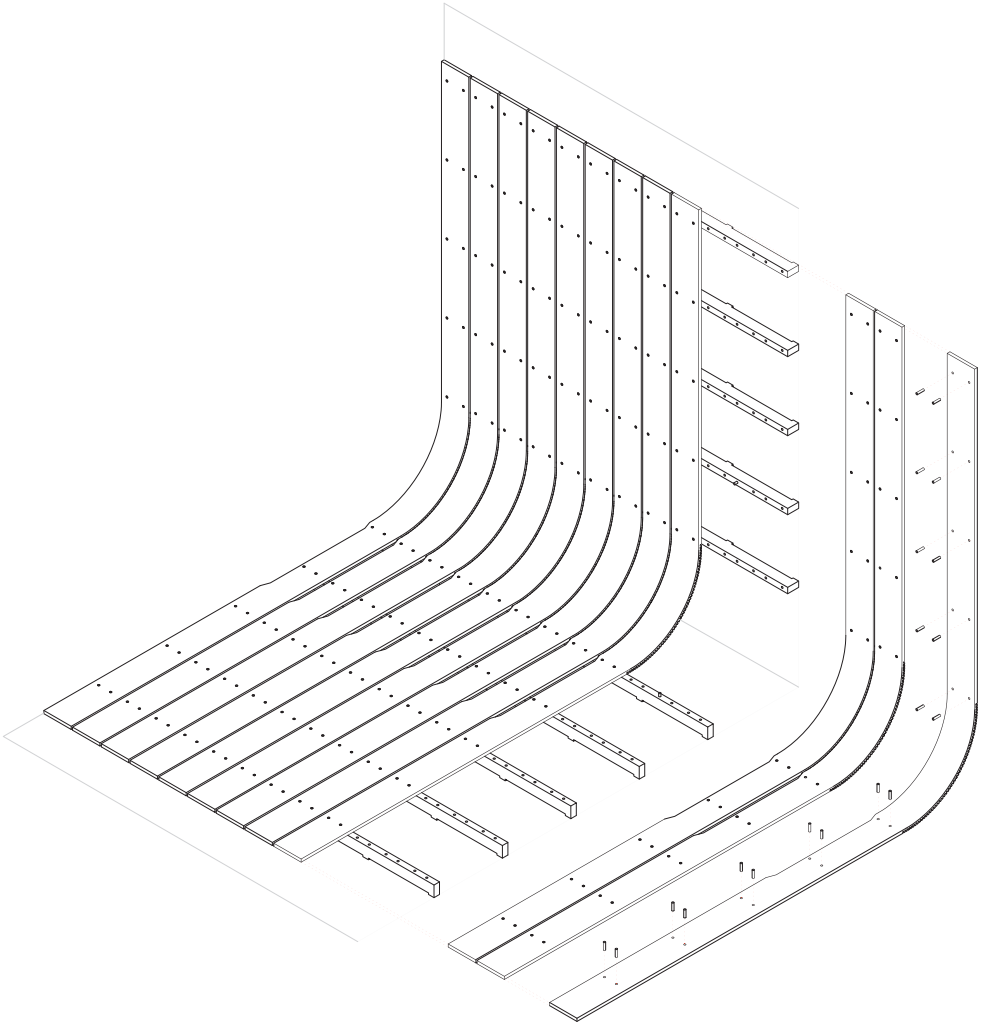

Bending Panel

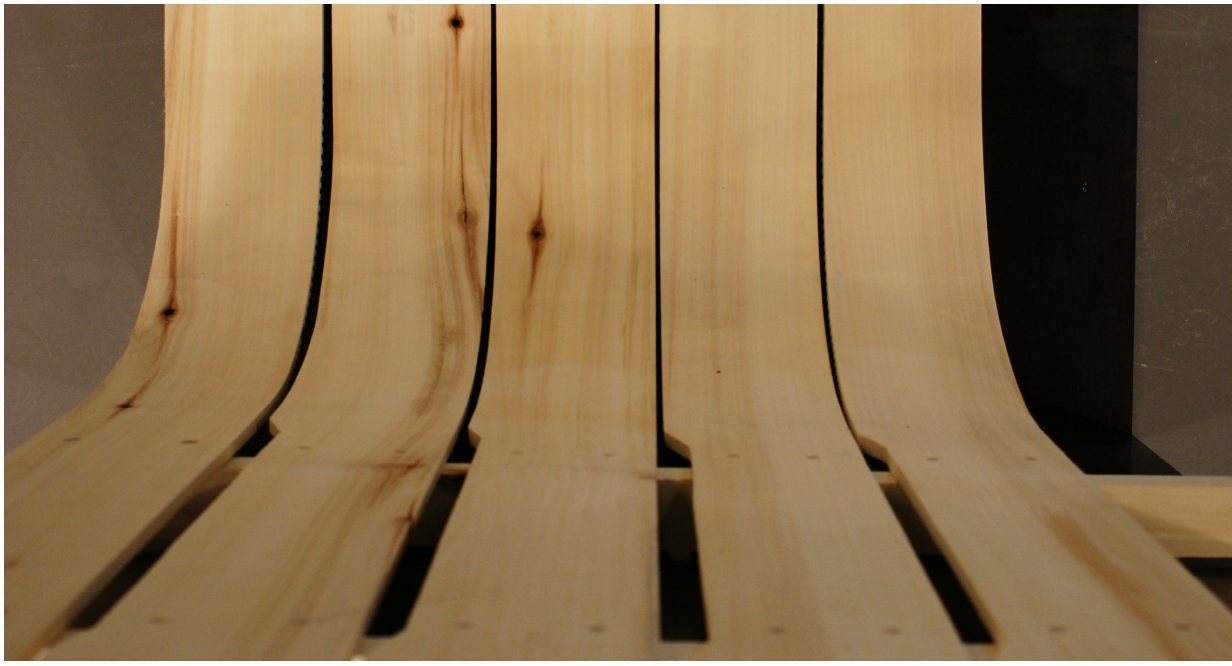
Tamminen Hoi Yee
Vallaster Tanja
Wirén Tiina
Wiegand Eduardo
Yao Yuchen
Zaera Fradera Robert

These multifunctional panels can be applied as cladding throughout the bathroom. They consist of boards that are bent in the corners of the room and are attached to a substructure, both are in aspen. The panels can be used in various ways to create unique, curving wet spaces with wooden, waving surfaces. The same panel can be used as floor, wall and ceiling cladding and can be transformed into furniture as well. The bend is created by soaking the boards in hot salt water for 24 hours and aided by cutting the wood creating incisions.

Aspen has a good natural endurance in wet spaces and has traditionally been used in wooden roofs. It also has a beautiful light colour and the soft, sanded surface feels warm and pleasant to the bare skin. We wanted to create safe and healthy wooden surfaces and avoid the use of unhealthy chemicals. The boards and substructure are naturally treated with salt using a traditional method. The substructure is cut into a profile that ensures good ventilation and allows the whole structure to thoroughly dry. The substructure is cut along the grain and the more moisture-sensitive end grain is raised off the ground. For the shower the boards have larger gaps to allow water to run off below the structure.

Space:	Bathroom
Type:	Panelling
Specific use:	Floor, wall, ceiling, furniture elements
Materials:	All wood
Species:	Ash
Treatment:	Salt-soaking
Effect:	Hydrophilic capacities added to the wood - protection from cracking
Boards:	100mm wide, 10mm thick
Bending:	5mm deep incisions
Substructure:	40mm high 20mm wide
Geometry:	5mm high incisions to create footing
Connections:	Oak dowels





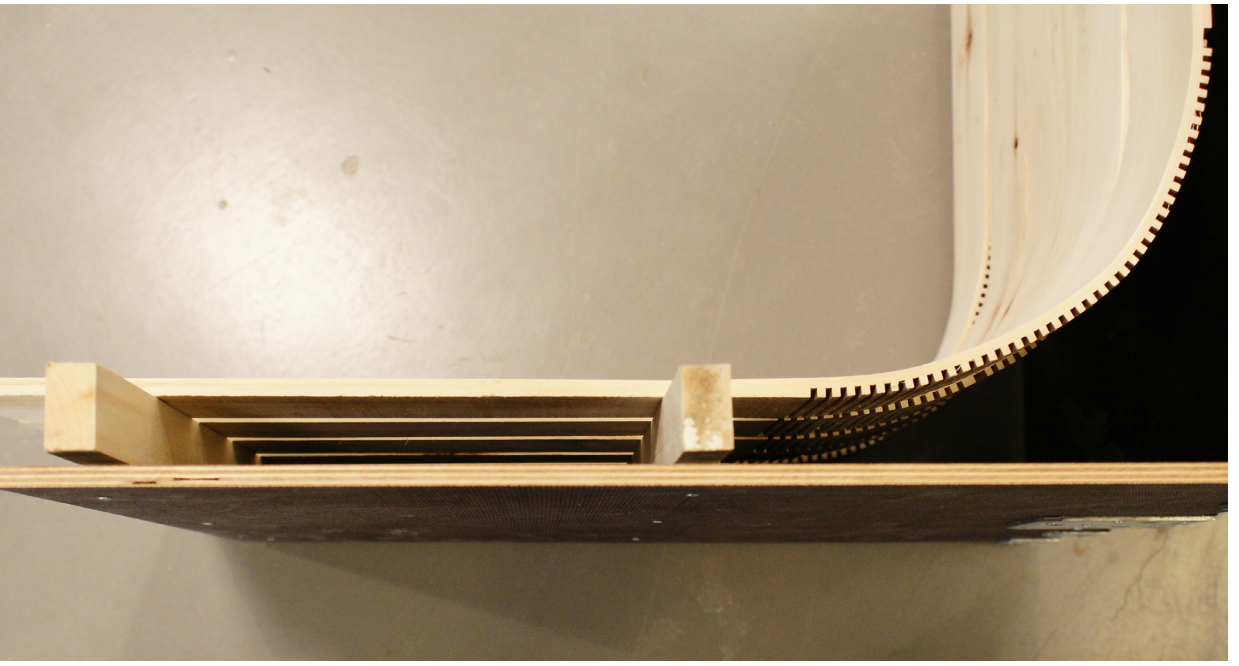
SALT TREATMENT

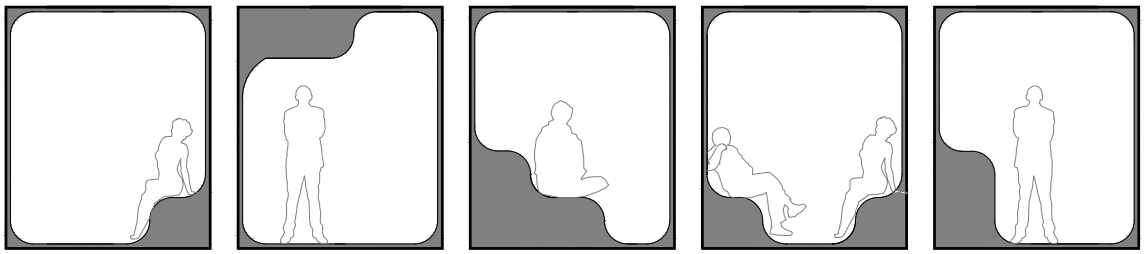
In a bathroom, it is important how the surface feels under bare feet. We wanted to maintain the natural feeling of wood while giving it the necessary protection from moisture. To maintain and protect the wooden surface, we treated the panels with salt. Salt treatment is a water-soluble treatment method, which is nonreactive with the wood and essentially displaces water in the swollen cell wall and reduces the humidity or activity of the water in the cell wall, thereby reducing its humidity expansion coefficient. When wood is soaked in concentrated solutions of these chemicals, they leach into the cell wall, displacing some of the water. Because of the reduction in the activity of the remaining water and the bulking effect of the chemicals, the wood remains almost fully swollen at relatively low ambient humidity. Salt penetrates the wood and makes it more hydrophilic this allows the wood to dry more slowly, protecting it from cracking.

In addition, the salt creates an antimicrobial surface which makes it harder for fungi and mould to grow. The bacterial adherence to a salt-treated surface is reduced in comparison to an uncoated surface by about 30 percent. This is important in a space where the importance of hygiene is high. It also seems like the most natural way of treatment as it has no harmful side effects in close contact with the human body. Also the reaction of salt and water is well-known and safe. The deformations and reactions with water has been well tested through the design process and the deformations vary in a manageable range of 1-3 mm, which does not affect the use or durability of the panels.

For the salt treatment the wood is immersed in hot salt water overnight. This has the added advantage that the treatment can be applied in the same step as the soaking in preparation for bending. The surface is then sanded and is attached to the substructure with no additional coatings or surface treatments. This is how the surface has all the good qualities of aspen – it leaves the boards with their natural, light colour, feeling smooth and warm, and having the pleasant scent of wood.

It was important for us to create a bathroom floor surface that does not get slippery when wet and this was ensured through multiple tests in the design phase. The wooden panel surface feels significantly warmer compared to commonplace ceramic tiles, for example, and maintains good friction under bare foot even when the wet. Additional roughing of the surface or grills proved to be unnecessary.



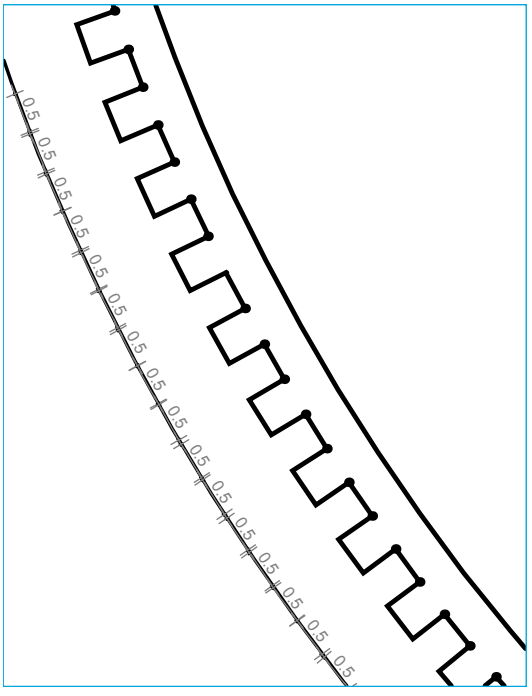


Organic and unique spaces can be created by applying the bending panels in various ways

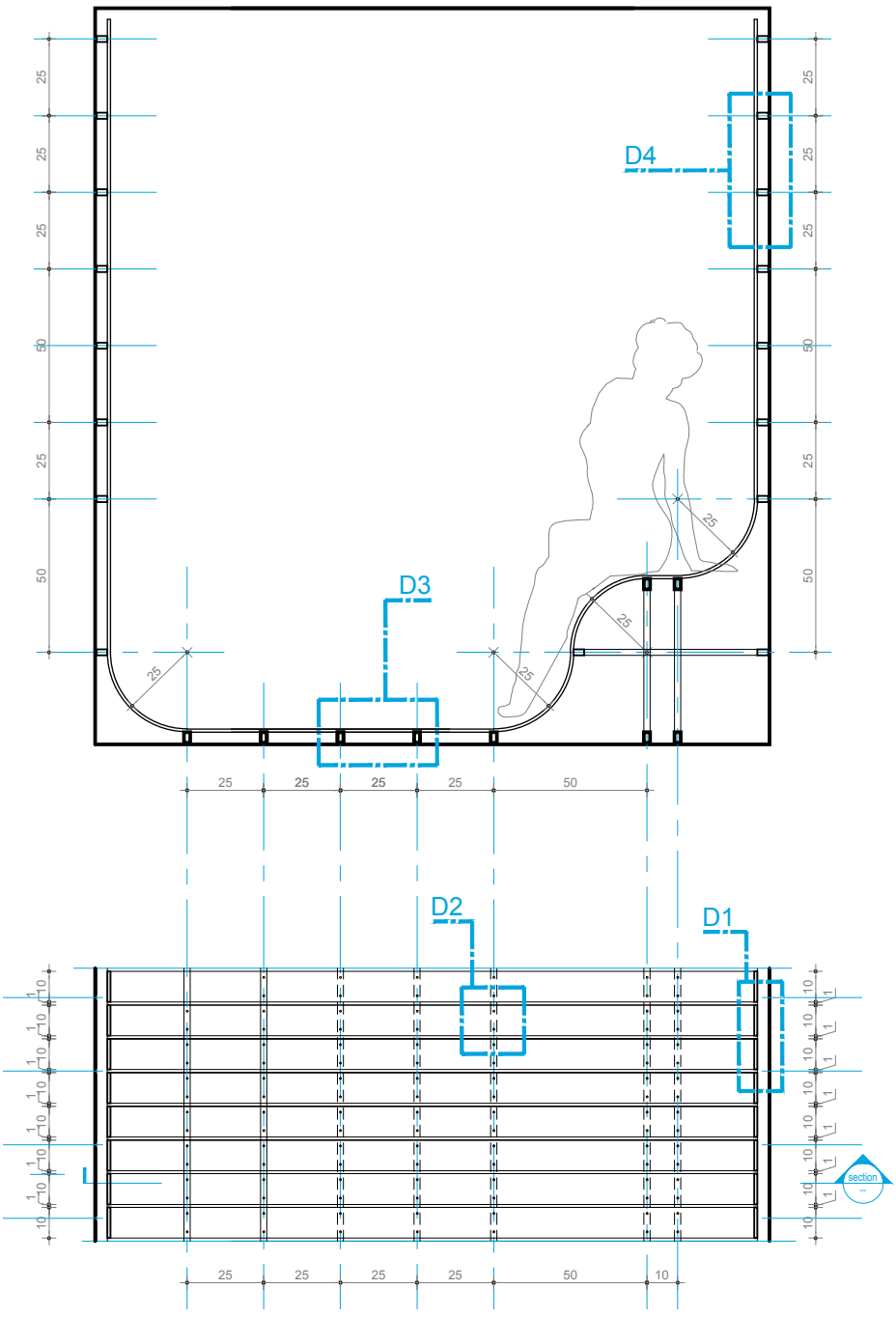
BENDING

The boards are soaked in a tank of hot salt water for 24 hours. The boards are then bent against a hot metal pipe and fixed to a 90 degree curve with a 25 cm radius. The pieces are left to dry and cool off in the mould for another 24 hours.

Different cuts and profiles of the boards were tested through the design phase. We discovered that the boards could be created with the smoothest curve when the incised cuts were made on the compression side of the bent board. This means, however, that the cuts face the bathroom. In the current design we concluded that this kind of surface would be hard to maintain and clean. The decisions about the dimensions and thicknesses were based on test results and mock-ups. The current dimensions of the boards were dictated by the ability to bend the boards and by their load-bearing capacity. Boards thicker than 8mm made bending impossible, whereas boards thinner than 6mm were not strong enough to carry load. The solutions are boards of 10mm thickness with incisions cut to a depth of 5mm.



A toothing is cut for curving the boards



Section and plan 1:20

SUBSTRUCTURE

The 10cm wide boards are from radially cut aspen heartwood. The boards are planed to a 10 mm thickness and a 5mm deep and wide incision is cut to the part that is to be bent.

In the case of the shower flooring, a 10mm wide cut is made in the boards. The excess water pours through the structure and the critical end grain meeting of the two board is moved further away from the source of water, allowing the water pass through the structure before reaching the joint of the flooring boards.

The bent boards are connected to the substructure with wooden dowels. This creates a holistic wooden surface that acts as one element in reaction to water and possible ensuing deformations.

The boards can be held together without glue or other chemicals that might not act well with water. Also, no metal parts are needed in the connection of the boards thus there is no risk of rusting on the surface of the panels.

The substructure is cut from 40mm high and 20cm deep solid aspen. The substructure in the floor is cut to a profile that has 10mm x 20mm supports every 250mm. The rest of the structure is lifted slightly above the ground to allow the water to run freely under the floor towards the drain. This also minimises the surface that is in contact with ground and allows the structure to dry easily. The end grain of the wood, which is most sensitive in regard to water absorption, is directed towards the walls and lifted above the ground.

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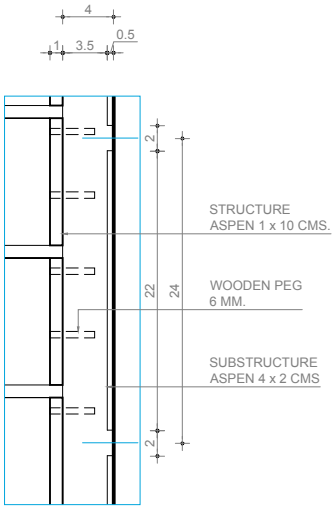

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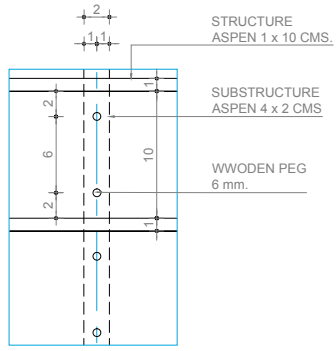

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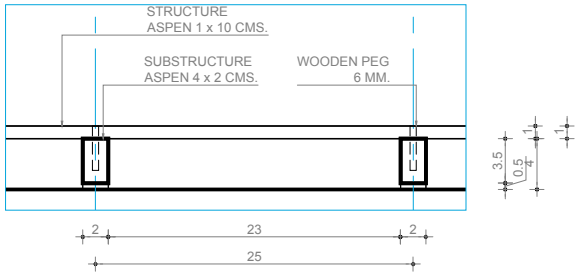

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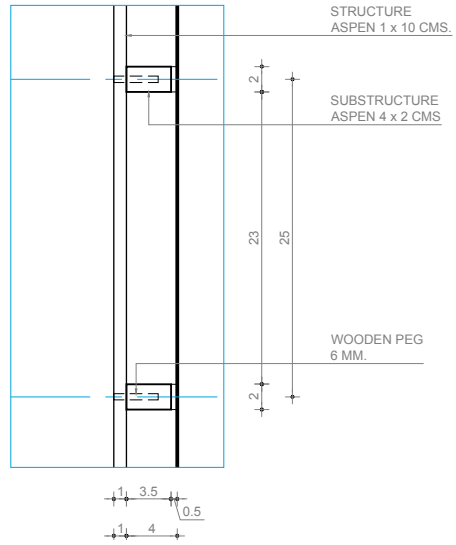

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Paanu Revisited

Mervi Antila

Paanu Revisited is a wall tile system for moist environments such as spa areas or bathrooms. It is constructed from aspen tiles which have 3 different profiles. The basic tile is a simple rectangle (size 20x10cm). The other shapes that I used have round and octagonal (size 25x10) endings. There were plenty of other profiles to use but I decided to start with more simple ones and see what I could do with them.

My design was inspired by the bold medieval rooftops of Finnish churches and a decorative shingle architecture, called Chilotan which emerged in Chile. Chilotan shingle architecture is known for its rich usage of different shingle patterns and colours. The shingle technique has been used widely all over the world for roofing and siding applications of houses but not that much indoors which is rather interesting because it is made to provide long-lasting weather protection.

In my project I wanted to explore the possibilities of using the technique indoors and in this case, moist environments. I was looking into simple installation techniques but a bold look. Usually shingles (or shakes) are attached straight onto a surface or to an installation profile with nails but I wanted to find a dismountable and more rapid way to install the tiles.

The simplest technique I could think of was to use gravity. The assembling profiles and wall splinting were shaped so that the tiles simply depend on the splinting. The next layer will then wedge the previous layer into its place.

Shingles which are used on roofing and siding are often quite thin. The thickness varies from 9.5 mm to 19 mm and there are few techniques to cut individual shingles in the right way. Because of the thinness of the material and ways of cutting, the appearance of a shingle wood surface is quite rough and uneven.

To avoid the irregular appearance, I decided to use 6 mm thick "shingle" tiles which immediately give a sharper look to the wall and emphasizes the different profiles.

Some of the shapes are highlighted with colour but otherwise the surface will maintain its natural aspen colour.





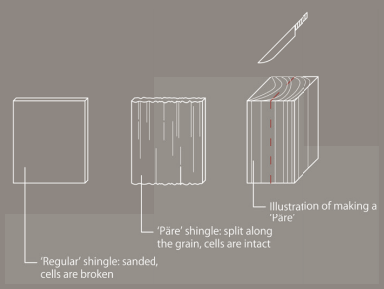
Ignacio Traver
Mikko Hakola
Sini Koskinen
Yllka Kuçuku
Yuko Konse

Päre in The Shower

Our project is an application of the 'PÄRE' shingle system (normally used outdoors) to interior wall surfaces in wet spaces like a shower wall. This project aims to make use of the qualities of wood and its structure and use them to our advantage by providing a water resistant surface that is aesthetically pleasing and a translation of a traditional solution into a modern setting.

Wooden shingles have been and still are used in roofs because of their efficiency, so why not try and apply the same theory to an interior wet space? We were interested in exploring the idea of applying an old but yet successful technique to the interior of a shower so we started to look more closely to the possibilities of this idea. In a shower we would normally have tiles that cover the wall. In the same way the shingles would compose the 'tiling' of our wall and therefore a size of 10 x 10 cm of visible area was agreed upon (as part of the 'unit' that is covered by the next one and so forth) as well as a smaller overlapping of the shingles.

Another element that we wanted to explore was the aesthetic one. While none of us was very familiar with the process of heat treatment we found it was the missing component to our project. It would provide the 'texture' of our wall by creating a 'pixelated' pattern. Heat treatment leads to changes in the colour of the wooden surface depending on the exposure time, it improves dimensional stability and increases the hydrophobic effect of the surface.



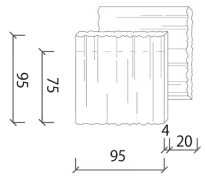
A 'päre' or shake is a split shingle, a thin timber cladding or roofing tile made by splitting a short log of timber along the grain.

By doing so the cells of the wood are not broken but remain intact, therefore the water absorption and dimensional changes are minimal. Also the texture of the material has a more 'natural-feel' to the touch (compared to regular shingles where the surface has been sanded) and provides an interesting wavy but smooth texture.

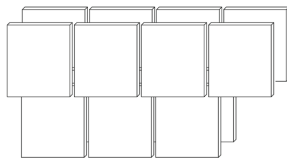
The shingle is composed of two overlapping shingles with different grain directions to minimize the dimensional changes due to moisture variation. After all the shingles have been heat treated, they are paired into groups of two and glued together, with Bostik adhesive for outdoors.

Dimensions / Wood species:

9.5 x 7.5 x 0.3-0.4 cm of the visible part. The shingles overlap by 2 cm and the one on the back has the grain running horizontally and the one on the top vertically. Spruce was used throughout the testing up till the final product.



Shingle



Assembling technique

Unit structure:

The split shingles were industrially manufactured and provided by Karipäre. The dimensions of the material provided was approximately 11.5 x 37 x 3-4 cm. We resized the shingles to our final dimensions by sawing and sanded the ends to result in a smooth finish.

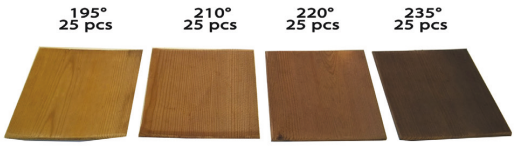
FIXING

The scaling of the elements was conceived to allow nailing to be concealed as well as to protect the nails from the water. This made it easy to fix them with nails using two nails per shingle. Due to the thickness of the shingles provided, as well as the material loss from the heat treatment, the fixing was in this case done with a nail gun (with the nails being thin enough to ensure that there was no cracking of the structure), resulting in a much faster and clean end result.

TREATMENT

To simulate the commercial Thermowood® process, an Electrolux air-o-steam cooking oven was used. The process was started with initial drying step at 103 °C and 0 % relative humidity (RH) for one hour. This was followed by the actual heat treatment at high temperature as well as 100 % RH for three hours. Four batches with different peak temperatures (195, 210, 220, 235 °C) were prepared to acquire shingles of varying colours.

Lastly this heat treatment step was followed by a relaxation step at 100 °C and 100 % RH for two hours to prevent cracking.



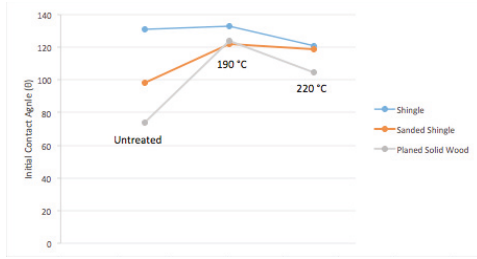
Color sample of each temperature

TESTS

a. Contact angle measurement:

Split shingles, sanded shingles and planed wood samples were tested untreated and after heat treatment at temperatures of 190 °C and 220 °C. The purpose of this test was to investigate whether the intact surface cell structure of unmodified shingles provides more preferable moisture absorption properties for the constructed wall. Also the effects of heat treatment were studied.

The split shingles proved to be more hydrophobic and less prone to wetting than sawn elements. Heat treatment increased hydrophobicity and decreased wettability in all the samples studied and treatment at 190 °C turned out to be the most preferable temperature for this.



Contact angle of different samples

b. Shower-cycle test:

Since the use of the ready piece would be in a shower space, we decided to conduct a shower-cycle test. For this test we made a 30 x 30 cm demo-piece that was subjected to 20 showers of 10-20 minutes duration. After a week the damage was investigated and the piece was dried at 103 °C. After drying the damage would be observed again as well to see if there was significant moisture still remaining in the structure.

After every shower and a short drying time, the shingle part of the test piece felt dry to the touch as opposed to other parts that were still wet.

During the pilot-scale test the shingles in the wall piece bent slightly more and also minor cracking had occurred. No sign of mould or standing water was observed. When the wall piece was dried at 103°C cracking and bending of the shingles became more extreme. The glue-line of the constructed pieces remained unbroken which resulted in severe internal tensions. Overall the piece was in a relatively good shape and could potentially be used for walls in wet space, maybe preferably not directly under running water.

Sensory Experiences of Wood: Achieving The Energy Efficiency and User Satisfaction

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Many people prefer living close to nature, which is regarded as an evolutionary instinct. Nature does not only provide the means for living but can also support physical and psychological wellbeing. Wood, either processed or living wood, is considered to be an intrinsic part of nature or wilderness and has many psychological benefits such as restorative, stress reducing effects and an ability to improve wellbeing and mental health. Research has shown that living close to nature has beneficial mental and physical health outcomes. Wood product manufacturers and designers are also aware of the importance of the perceived naturalness of the material which is pivotal to consumer preference and satisfaction.

Although the restorative benefits of wood has gained attention during the last few decades, research on the primary sensational experiences of wooden surfaces has remained largely unexplored. Therefore, our work in the Aalto Energy Efficiency Programme, WoodLife project (2013-2017) has focused on an exploration of the tactile and visual qualities of wooden surfaces. We aimed to study the sensory perception, emotional touch and thermal comfort of wooden materials to gather a novel understanding of the unique sensory characteristics of wood. The findings can potentially be used to promote the use of wood in interior spaces and possibly even to reduce energy consumption.

TACTILE AND VISUAL SURFACE QUALITIES: WOOD FEELS AND LOOKS GOOD

What we experience perceptually is rooted in the sensory input that we receive through our sense organs. Sensa-

tion provides a first-hand impression of the physical world and our hedonic choices i.e. instantly liking or disliking something based on sensory attributes. These hedonic choices have the ability to influence and guide our decision-making processes, whether they are rational or intuitive. Therefore, it is important to consider how people sense the wood by different sensory systems. It may be hard to define to what degree the sensory information coming from different sensory systems contributes to the overall perception. At least partly, these processes depend on the tactile and visual qualities of matter.

Wood feels good when touched. Recently, we conducted an experiment to study the emotional touch of wooden surfaces (see Figure 1). People perceived the wood-touch in an extremely positive way, especially the smooth and uncoated surfaces of both pine and oak boards, that were evaluated more positively than the coated surfaces. For coatings we used double-layered varnish and wax. Varnish was applied by brush and wax by a piece of cotton cloth. The results can be utilized to improve the surface qualities of wood to get better positive evaluations by users and to eliminate the negative touch attributes.

THERMAL SENSATION AND THERMAL COMFORT

A good thermal quality of the material in the living space is determined by its higher heat capacity; an ability to store the heat energy, and lower thermal conductivity; rate of heat flow. Thermal conductivity determines a materials' ability to exchange heat: a higher thermal conductivity value leads to a higher exchange rate and a lower value reduces the rate. Wood has a lower thermal conductivity than most other typical building materials like cement, concrete, iron or stone. Wood has also an excellent moisture buffering capacity that helps to regulate the heat exchange process in extreme temperatures. It takes a lot of

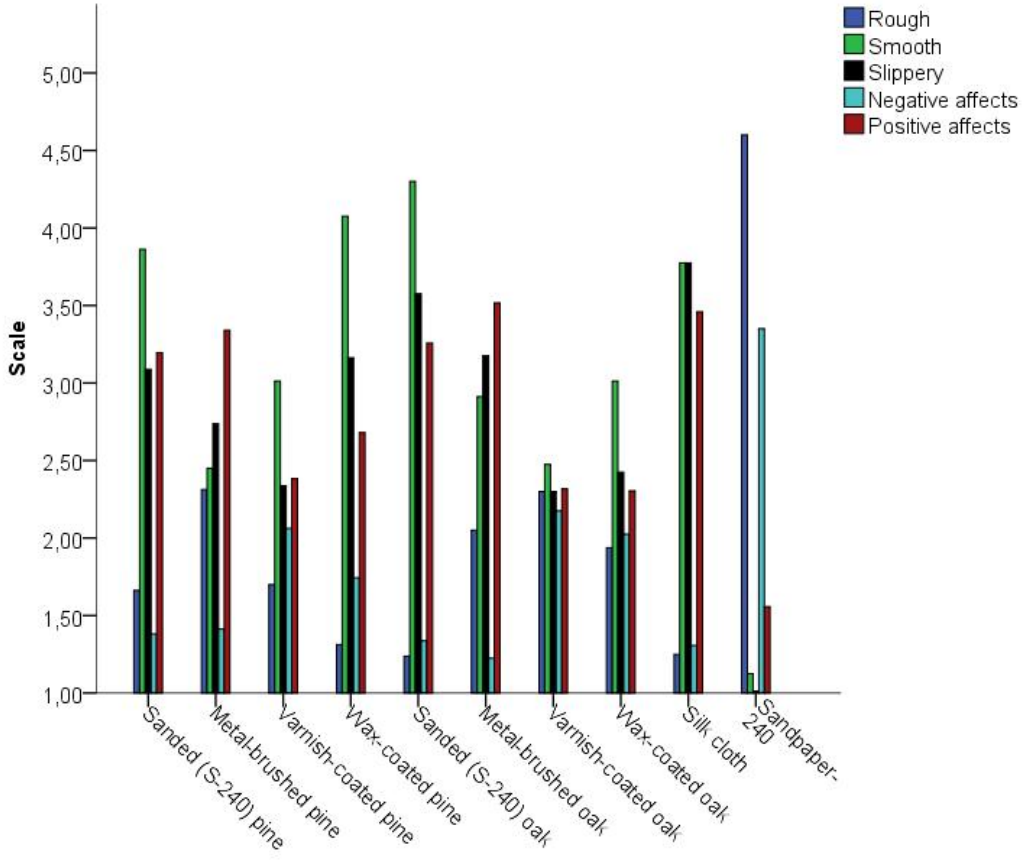

Figure 1. Haptic touch evaluation of various wood surfaces. Negative attributes were measured by the words irritating and discomfort. Positive attributes were measured by the words comfortable, enjoyable, calming, desirable and relaxing. Scale: 1- not at all to 5 - highly likely

time to cool down a home built of wood in harsh winter weather and warm it up in the summer because of the good thermal mass of wood. Therefore, the gradual changes in internal room temperatures give more time for inhabitants to acclimatize and get used to the changing weather conditions. Another important factor in the perception of the warmth or coolness of living spaces is the relative humidity of the air. Again, the excellent moisture buffering capacity of wood helps maintaining an optimal level of humidity.

We conducted a series of psychophysical experiments to determine the perceived warmth of a variety of wood species and how the perceived warmth is influenced by various wood treatment/modification methods. The preliminary results show that various wood surface treatment methods can influence the thermal quality and its perception. We also compared the wooden surfaces with non-wood floorings to identify suitable materials for various interior spaces, for example bathrooms and kitchens. Our main aim was, however, to find ways to increase the use of

Figure 2a. A thermal discrimination test setup; participant's side view

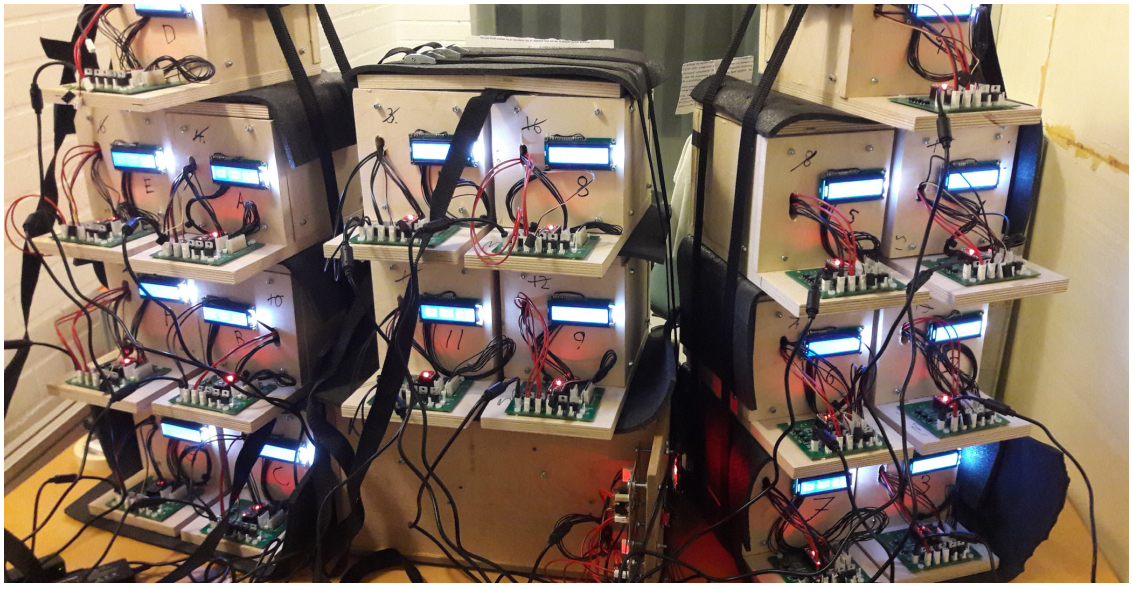

Figure 2b. A thermal discrimination test setup; experimenter's side view

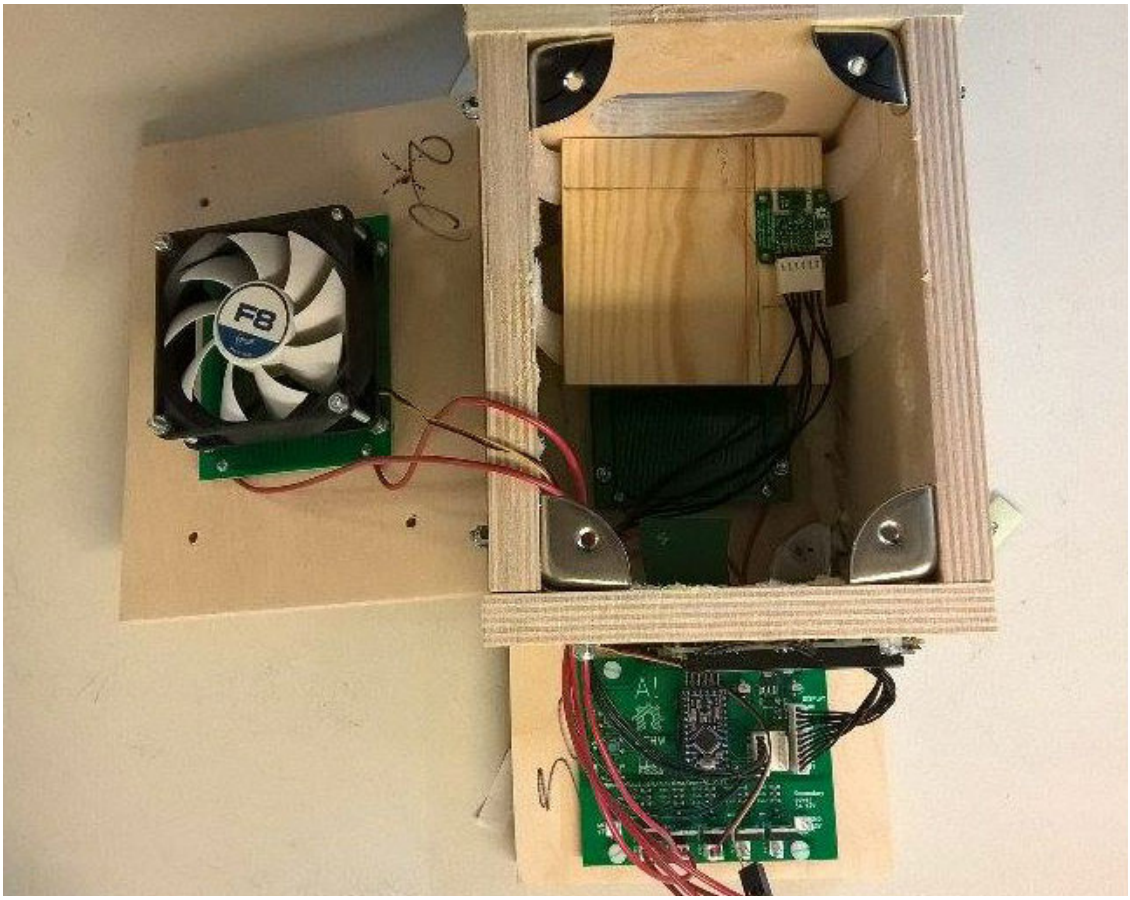

Figure 2c. A thermal discrimination test setup; a unit box showing heating elements , temperature sensor, and test sample installation, a unit box is used to warm the test samples in predefined temperature precisely (±0.1)

The heating elements (temperature sensor boards) were designed by a group of students from the Department of Mechanical Engineering under the supervision of senior Lecturer, Panu Kiviluoma, for their course exercise. Please follow the link below to get more information about the temperature sensor board: wiki.aalto.fi/display/MEX/Temperature+sensor+board

wooden materials to save a significant amount of energy in a passive way and at the same time stimulate positive living experiences.

Once we ranked the various wood and non-wood flooring materials on the basis of the differences in perceived warmth, we measured that difference through a series of thermal discrimination tests. The aim was to identify the point of subjective equality (when two different material surfaces were felt to be equally warm although they were at different temperatures) in the thermal perception between ceramic tile, pine and oak wood surfaces. The concept of subjective equality provides an idea for calculating (theoretically) the amount of energy saved by using materials having good thermal insulation. For instance, if a wood surface at 20 degrees and a ceramic tile at 23 degrees feel equally warm, then the amount of heat energy required to warm up the living spaces by 3 degree can be saved by using the wood instead of the ceramic tile. The preliminary results showed that a significant amount of energy could be saved by the increased use of wood in the building constructions.

In conclusion, creating a healthy, sustainable and energy efficient living space is possible by the smart utilization of wood.

Health and Wellbeing in Indoor Environments

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INTRODUCTION

The study of wood and health is a new field in the area of the indoor environment and related health outcomes linked to the built environment. The number of studies on the topic is limited, and as such the depth and breadth of the research is relatively small compared to other topics in the environmental research literature. The literature on environmental research provides a clear connection between the presence of natural elements in the built environment and positive health outcomes. This article seeks to give a short review of environmental research, highlighting studies on the use of wood in indoor settings. Research in projects at the Norwegian Institute of Wood Technology (Treteknisk) is presented in detail. Finally, the research at Treteknisk and on wood in the indoor environment in general is put into context, discussing the results, shortcomings and suggestions for further research.

ENVIRONMENTAL RESEARCH LITERATURE REVIEW

There is a large body of environmental research literature that, directly or indirectly, shows that environmental design can affect an individual and/or work needs (Rashid and Zimring 2008, 155). Several reviews of the literature on how the indoor environment and natural elements affect health and wellbeing have been carried out (Salonen et al. 2013; Sakhare and Ralegaonkar 2014; Bringslimark, Nyrud, and Aslaksen 2012; Berg 2005; Frandsen et al. 2009; Rashid and Zimring 2008; Bringslimark, Hartig, and Patil 2009), as well as a few reviews of the use of wood in indoor settings (A. Q. Nyrud and

Bringslimark 2010; Augustin and Fell 2015; Burnard and Kutnar 2015).

INDOOR ENVIRONMENT, HEALTH AND WELLBEING

Salonen et al. (2013, 6) summarised the scientific evidence on the effects of environmental factors in health care settings. Strong evidence was found that the acoustic environment, ventilation and air conditioning systems, the thermal and visual (e.g. lightning and views of nature) environment, ergonomic conditions and furniture have beneficial effects on human wellbeing. Special layouts, room type, and floor coverings can on the other hand can be beneficial to one group while detrimental to other groups.

Rashid and Zimring (2008) reviewed the literature on the relationships between indoor environments and stress in health care and office settings. The review shows a significant amount of work on the psychological, physiological and cognitive effects of noise, especially in office settings. The literature on the effects of lighting were found to be ample in both office and health care settings. The results unambiguously show that daylight is important for human health.

Strong evidence was also found on the effect of temperature on task performance, environmental control and worker satisfaction, but few studies report on the psychological, behavioural and social effects of temperature, especially in health care settings. Even though more research had been carried out in office settings, the results were ambiguous. For the effects of air quality there are many studies in both office and health care settings.

REVIEW OF LITERATURE ON THE USE OF WOOD IN INDOOR SETTINGS

Nyrud and Bringslimark (2010) reviewed the literature on psychological responses toward wood, and provided an introduction to theories of why the use of wood may have a psychologically beneficial effect for people in indoor and outdoor settings. Wood in indoor settings included flooring, panelled ceilings and walls, and also furniture made with sawn wood, engineered wood products and wood-based panels.

Several previous studies over the past decades have documented that nature or elements of nature can have beneficial effects on human health and wellbeing, both indoors and outdoors. Three main areas of study have mainly been the focus of studies on the psychological benefits of interior wood use: Perception; attitudes and preferences; and psychological responses. In general, people have positive attitudes towards wood and the use of wood in interiors.

The literature review showed similarities in preferences for wood, and wood being a natural material as the main reason why people prefer it. Given the psychologically beneficial effects of wood, affective responses towards wood seem measurable. However, due to the few studies with the same outcome measures, the authors suggest caution in concluding that the use of wood is psychologically beneficial.

Augustin and Fell (2015) wrote a research overview on wood as a restorative material. The review covered articles on wood in healthcare settings, psychophysiological responses to wood, self-reported studies and unpublished research in English. The results from the limited amount of articles reviewed are similar to results from studies on plants and other natural element. The authors conclude that "we are healthier, happier, and more productive when connected with nature"(Augustin and Fell 2015, 21). Lower levels of stress, lower heart rate and skin conductivity, and higher heart rate variability were found to be linked to exposure to wood.

Burnard and Kutnar (2015) built on the review by Nyrud and Bringslimark (2010), and examined the research studying wood use and human stress. Both previous studies on the psychophysiological responses to wood and methods for assessing stress in experimental settings were reviewed.

Though few studies directly examining psychophysiological effects of wood on human health were found, all but one of the studies concluded that wood generally has a positive effect on occupants. Many of the studies covered in the review were found to have limited sample sizes, but the results could provide useful indications for further research in the field.

As a restorative element in design, the authors concluded that wood can address each of the six tenets of biophilic design: As a recognizable natural element wood provides a direct link to nature; Patterns in the wood grain have natural shapes and forms; Grain patterns, knots and the colour spectrum evoke natural patterns and process; The colour diversity and ability to be deployed in products without losing its familiarity as a natural product; Using locally sourced wood can evoke a connection to nature through historical and regional building methods; Wood has for millennia been used by humans as a source of shelter, tools, transportation, and as art.

RESEARCH AT TRETEKNISK

The effects of using wood in indoor environments on human health and wellbeing has been the subject of several research projects at Tretek-nisk. In collaboration with other research partners, projects have involved focus groups investigating perceptions of the indoor environment and preference studies among health care professionals.

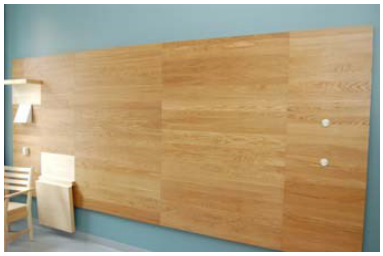

Figure 1. Wood Room

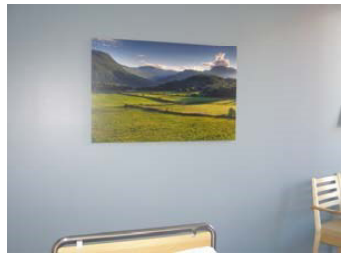

Figure 2. Landscape Room

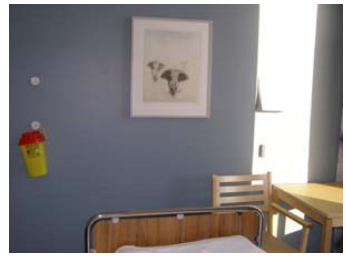

Figure 3. Artwork Room

PREFERENCE FOR WOOD INTERIOR IN A HOSPITAL ROOM

Previous research indicates that the built environment has a fundamental effect on people. Preferences for a setting are thought to be indicators of factors in the environment that can enhance health and wellbeing. Nyrud et al (2014) investigated preferences for natural building materials in patient rooms. An online survey was distributed to employees in one department at a Norwegian hospital. The respondents were asked to evaluate ten computer-manipulated pictures of patient rooms with different amounts and dispositions of wood on the surfaces.

The results indicated that rooms with an intermediate level of wood was most preferred the most. The rooms at both ends of the continuum, those with either no use of wood or all wood, were preferred the least by the respondents.

The results indicate that the amount of wood used in interior design is important. It is neither necessary, nor beneficial, to use as much wood as possible. The study show that design influences the user experience, and possibly has expected health benefits.

THE USE OF NATURAL MATERIALS, LANDSCAPES AND ARTWORKS IN PATIENT ROOMS

The use of landscapes and artwork has been a key part of developing the new St. Olav's Hospital in Trondheim. A study (Bringslimark, Nyrud, and Aslaksen 2012) was conducted at the hospital to investigate wellbeing in patient rooms and whether the use of natural materials, landscapes and artworks in patient rooms has any measurable effect. Other factors that were examined were views from windows, light, the perception of noise and air quality, as well as the perception of the patient room as a whole.

The subjects selected for the study were some 271 patients in the Department of Orthopaedic Surgery at St. Olav's Hospital. The majority of the patients had undergone surgery for knee or hip replacement. The average patient age was 60.6 years and 178 women and 93 men participated in the study. All patient rooms in the department were single occupancy rooms. The patients were randomly distributed among three different patient room types:

1) Wood Rooms, which included considerable amounts of visible natural materials (see Figure 1),

2) Landscape Rooms, with a large landscape picture (see Figure 2), and

3) Artwork Rooms, which were standard patient rooms decorated with a work of art (see Figure 3).

A wood panel was installed in five of the rooms, four rooms were decorated with landscape pictures, while seven rooms had artworks on the wall. In all, there were 80 patients in the Wood Rooms, 81 patients in the Landscape Rooms and 110 patients in the Artwork Rooms. Outcomes comprised data from questionnaires and information from patient journals. Information was extracted from the questionnaire about emotions before and after the operation, self-perception of pain and evaluation of the room the patient occupied. The data extracted from the patient journals consisted of the length of hospitalisation, blood pressure and the use of painkillers.

The results showed that the patients were very content with the new patient rooms at St. Olav's Hospital, indicated by averaged scores for the various elements on the room evaluation scale. On a scale of 1=Disagree completely to 5=Agree completely, the rooms were evaluated as very positive. The highest average score was for "I like the room" (M=4.47) followed by "Pleasant" (M=4.42), "Nice" (M=4.40), "Safe and secure" (M=4.38) and "Light" (M=4.37). "Airy" (M=4.17) had a slightly lower average score than "Modern" (M=4.21). Furthermore, the rooms were perceived as having "good air quality" (M=4.11) and patients were not bothered by "Unpleasant smells" (M=1.54) or noise since the rooms were largely perceived as being "Quiet" (M=4.04). The rooms were to a lesser extent perceived to be "Boring" (M=2.20).

In general, the results show that the patients were very satisfied with the rooms as indicated in the average scores for the different elements in the room evaluation scale. The Wood Rooms were

seen as significantly less boring and ordinary than the Artwork Rooms, while the Artwork Rooms were significantly preferred to the Landscape Rooms. No measurable effects were found in the outcome measurements related to the different room types. One explanation for this is that the differences among the rooms were too little to result in any measurable effects. In addition, the hospital and patient rooms were completely new so that the general impression of all rooms was very positive.

A statistical analysis was performed to investigate whether there were any differences in room evaluations among Wood Rooms, Landscape Rooms and Artwork Rooms. Even though there was a statistically significant difference for this element, the actual difference in the average scores among the groups was small. The size of the effect indicated that the average score for the Wood Rooms (M=3.98, SD=.90) significantly differed from that of the Artwork Rooms (M=3.55, SD=1.16). Landscape Rooms (M=3.90, SD=.90) did not differ significantly from the Wood Rooms and Artwork Rooms for this element.

There are several results from the research that indicate a correlation between architecture and health, and that more humanistic and patient-oriented healthcare institutions can be significant for the patients' recovery process. It is nonetheless difficult to draw unequivocal conclusions on what constitutes the most optimal architecture and design. The reason for this is that how the physical surroundings in the healthcare facilities affect patients is a very complex process that implies a series of different variables such as the condition of the patient's health, as well as individual and organisational factors. This also implies that certain health-promoting factors cannot necessarily be transferred from one institution to another. However, the results from this study indicate that the physical surroundings, architecture and design in healthcare institutions do indeed have an effect on health and that these aspects ought to be considered when planning and designing new healthcare facilities.

WOOD USE IN A HOSPITAL ENVIRONMENT AND VOC EMISSIONS

Nyrud, Bringslimark and Englund (2012) assessed the impact of wood on indoor air quality in a hospital environment by measuring the air concentration of volatile organic compounds (VOC). A total of eight hospital rooms, with three different room designs were investigated. The designs had varying amounts and types of wood interiors.

In addition to VOC emissions, temperature and relative humidity were also recorded. The VOC levels were recorded before the patients moved into the newly built wards. The wall panels were mounted in December 2008, and again in August the next year. The patients moved into the rooms shortly after the second measurement.

The total VOC concentration were low compared to what might be expected for a newly furnished building. All rooms were in the range of 115–170 ng/l.

The study found that using wood in the furnishing of hospital rooms has a negligible influence on VOC concentration, meaning that the air quality and climate of the hospital rooms were not substantially affected by the wood interior.

FOCUS GROUPS

Focus groups are carefully planned group discussions designed to gather participants' views and opinions on specific topics. Each focus group usually consists of five to ten people and a moderator who, using an interview guide, moderates the group discussions. The interview guide is used to ensure that all relevant topics for discussion are covered during the focus groups.

The purpose of a focus group is to listen and gather information to better understand participants' perceptions and views. The groups are conducted several times to enable identification of patterns and trends. The analysis of data from the focus groups can provide clues and insights into how products, services and opportunities are perceived (Krueger and Casey 2000).

The focus group differs from traditional interviews with a predetermined questionnaire and closed-ended responses. With the moderator taking on a less directive and dominating role in the interview, using open ended questions, the attention is shifted to allow "individuals to respond without setting boundaries or providing clues for potential response categories" (Krueger and Casey 2000, 6).

BUILDING MATERIALS AND THE EXPERIENCE OF INDOOR ENVIRONMENT

The objective of the study by Nyrud et al (2010) was to gain insight in to how regular people view the correlation between building materials and the perception of an indoor environment. The focus group analysis was carried out by Treteknisk and Statistics Norway.

Four focus group interviews were performed. The groups were organized according to experience, gender and ethnic origin. All participants were between 20-40 years of age and a resident of Oslo or the surrounding area.

The participants in all four focus groups discussed what they perceived as a natural building material (i.e. close to nature or natural origin of raw materials) and how natural materials differ

from non-natural materials. The main criteria for characterizing a material as natural was that it does not contain chemical compounds and/or has not been subject to extensive processing. The use of wood as a building material is largely considered positive – especially when used as flooring. The materials must, however, fit into the environment in which they are used. Variation and contrasts in the use of materials has a positive influence on indoor environment.

The results showed that the most significant distinction between the groups was due to cultural differences. The non-Scandinavian group differed from the other groups. This was most evident when discussing flooring, where the participants with a Norwegian background preferred wood flooring, whereas the non-Scandinavian participants mostly saw disadvantages with wood flooring. Two of the groups had experience with renovating and building. The distinction between those with and without experience was mostly related to the practical user experience. Participants with experience were more technically oriented and were more realistic with relation to what they expected from the building materials. The biggest difference between men and women was related to ethical and environmental issues. Men are more pragmatic regarding these subjects and rely on public approvals as well as on the distributor, while the women are inclined to a more active approach regarding the environment and other ethical causes.

Burnard et al (2015) investigated user perceptions of building materials in Finland, Norway and Slovenia. A survey was conducted in each country to gather perceptions on 22 different building materials, including solid wood, engineered wood-based products, masonry, stone, wallpaper, ceramic tiles, metal and plastic. Solid wood, stone and brick were considered more natural than materials that were processed, e.g. metal, plastic and fabric.

The differences between country groups were minor, with strong statistical evidence for only two materials: Finnish respondents rated particleboard as less natural than did Slovenian respondents, and Norwegian respondents rated the WPC sample with imitated growth rings lower than did Slovenian respondents. There were no significant differences between Slovenian respondents in the cities of Koper and Ljubljana. The differences detected seemed indicative of a knowledge gap related to familiarity with wood products rather than culturally different attitudes and perceptions of material naturalness.

In general, all respondents had a relatively strong degree of agreement on the naturalness of the 22 building materials presented for their assessment. Solid wood, stone, and brick tile were considered to be natural, while the items with greater degrees of processing were consistently regarded as being unnatural (e.g. steel, plastic, ceramics). The respondent's perceptions of naturalness were consistent when considering materials they clearly believed to be natural and those they did not (e.g. solid wood and steel, respectively).

As architects and building designers make material decisions, especially when they seek to reflect experiences of nature, life, and life-like processes, they should consider user perceptions of building material naturalness. The apparent number of transformations and amount of additives may be more important than the actual transformations and additives present in a material. However, using materials closer to their raw state will likely ensure they are recognized as more natural than their heavily processed counterparts.

To maximize the positive impacts on building occupants, further research must examine the source of restorative effects in the built environment and identify the most suitable design solutions for implementing them. Experiments gauging occupant responses to stress, stress recovery, attention restoration, and other indicators of wellbeing should focus specifically on the environment in which occupants spend most of their time. An emphasis on the types of materials and how they are used in the built environment in these studies will provide designers with a stronger foundation for designing healthy environments and provide society with healthy buildings. Furthermore, replicating this study in other locations and focusing on subsets of material classes (e.g. wood) with more varieties within the class will further illuminate trends in people's perceptions of building material naturalness

BUILDING MATERIALS AND WELLBEING IN INDOOR ENVIRONMENTS

Focus groups were carried out in Austria, Finland, France, Norway, and Sweden to understand building professionals' and laypeople's perceptions of building materials and wellbeing in indoor environments (Bysheim, Nyrud, and Strobel 2016). The focus groups were moderated by researchers at Holzforschung Austria, Linköping University, Aalto University, BRE and The Norwegian Institute of Wood Technology.

The research questions for the study were:

- What is associated with a natural building material?
- Which building materials are associated with a good indoor environment?
- How does the use of building materials in the indoor environment affect the users?

In the focus groups, participants were asked to share their opinions and experiences related to seven main topics: choosing interior materials, naturalness, naturalness for building materials, wellbeing in the indoor environment, wood materials, cleanability, and ethics and environment. Two different interview guides were used during the focus groups. One guide covered topics for building professionals and other people with a background from the construction industry, and the other guide covered topics for groups with lay participants with various unrelated backgrounds.

In total, 60 people participated in the focus groups. Two groups consisted of students (16 people in total), one group had a mix of students and architects (8 people), 3 groups were made up of building professionals (17 people), and two groups had a mixed background and had 12 people participating. Also, one group with students and engineers (7 people) from Mozambique participated in the study.

As part of the assessment of naturalness, the focus group participants were given the task of ranking wood material samples for naturalness. Wood samples used in the task given to the focus group participants can be seen in Figure 4.

The majority of the focus group participants had the same ranking for the materials: from most to least natural they were: knot-free pine decking, painted pine, OSB, and then MDF (See Figure 5). While there were differences in responses between participants, the most common ranking was the same in all countries. An important factor for perceived naturalness was the level of transformation of the wood. Materials with visible fibres were seen as natural. Materials that were laminated or painted were seen as industrial or chemical.

Reasons given for ranking the knot-free pine decking as the most natural material: you can tell the origin of the material, the wooden structure is visible, it is the least processed sample, the sample still smelled like wood.

Wellbeing was another topic discussed in the focus groups. Participants mentioned many

Figure 4. Material samples used in focus groups. From left to right: painted pine, knot-free pine tongue and groove decking, oriented strand board (OSB), and medium density fibreboard (MDF)

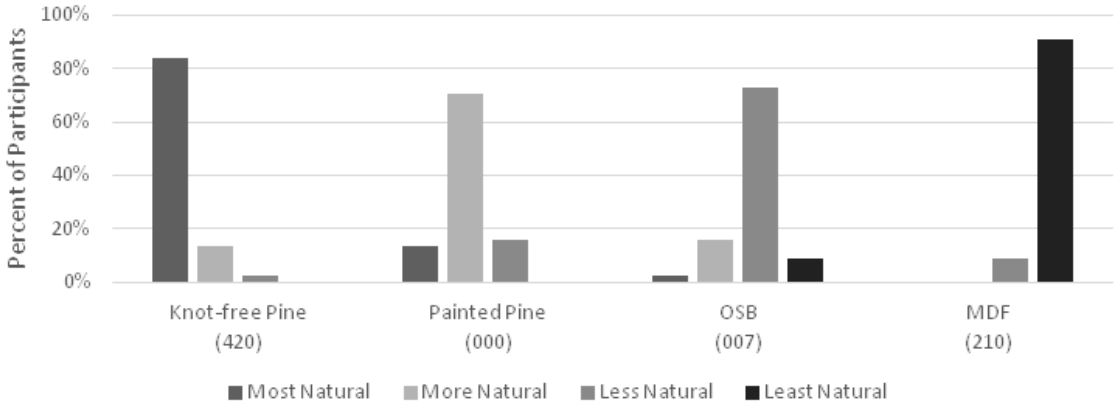

Figure 5. Material sample rankings (based on responses from 44 participants)

aspects of buildings that help to promote occupant wellbeing. Factors mentioned as being important to wellbeing include: light, materials, scent, sound, cleanliness, and indoor air quality. Open, bright spaces with lots of (day) light were seen as instrumental in how interior environments affect human wellbeing. Quality materials that bring warmth and an appropriate atmosphere to a space were also seen as important.

Respondents with no professional experience of building materials had different expectations for public and private buildings regarding wellbeing in indoor environments. Public buildings are expected to have a minimalist modern design, but homes are expected to be cosy and warm.

Participants from each of the countries generally held similar views. The appropriateness of interior materials was seen as dependent on building type and context, with a greater preference for natural materials, particularly wood, in residential construction. Different stakeholders had different priorities relating to cleanability and environmental aspects which were often assessed as being in opposition to cost and general aesthetics.

FURTHER RESEARCH/RESEARCH NEEDS

Rashid and Zimring (2008) observe that despite differences between environmental studies, e.g. between health care and offices settings, there are many reasons why comparing the results and methods can be useful. The authors suggest that although each study deals with different settings, the findings from one setting may suggest research opportunities and guide research in other settings. Learning from the strengths and weaknesses of various study designs may also contain important lessons for researchers.

Nyrud and Bringslimark (2010) conclude that not enough research has been conducted on which psychological processes produce psychological benefits in indoor settings. Theory development and in depth discussions of theory has not been a priority in the research reviewed. Preferences for wood types and characteristics, which are thought of as a proxy or indication for potential psychological benefits, have been the focus for many studies on the psychological effects of wood in indoor settings. The authors note the need for investigations into how shapes and forms found in nature are perceived and whether natural forms may generate psychological benefits, e.g. fractal structures. Also, a number of applied issues needs to be addressed. A knowledge gap on how to translate research findings on the benefits of using natural materials in indoor settings into guidelines for designing indoor environments that are beneficial to the occupants. Another area that is found lacking is the strength of the relationships between nature or natural elements in indoor settings and beneficial effects. More research is also needed on the spatial conditions and whether natural elements are beneficial in all settings. By integrating features of natural elements into the built environment more people can have access to nature to a greater degree. Because of this, and since research has found measurable effects from wood in interior settings, it is important to continue research on the psychological effects of interior wood use.

Burnard and Kutnar (2015) suggest further studies on specific aspects of wood related to the psychophysiological responses to wood. The colour, quantity and grain pattern of wood used in interior settings also need further examination. How the different types of wood and attributes of wood (e.g. colour, pattern, solid, composite) are expected to provide restorative effects to occupants, and the amount of wood necessary to have any effects on wellbeing remains a question. To be able to provide guidance on interior wood use, more research with stronger designs is needed to fill the gaps in the current knowledge.

Most of the reviewed research has been conducted in either healthcare or office settings. Results from the focus group research indicate that people have different preferences for wood use in different interior settings. The use of wood also affected preference for activities to be performed in different settings. Further studies of preferences and psychophysical effects in different environments could be interesting topics for further research. Also, studies on the psychophysiological effects of wood have been very few. Further exploration of this topic or replications of these studies is needed.

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